Evaluation of e-commerce website based on fruit fly algorithm optimization RBF algorithm

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Abstract

The feature and various index properties of E-commerce website are considered as a whole by applying the expert grading method, with the construction of the multi-index hierarchical structure of an E-commerce website competitiveness index evaluation and the establishment of an E-commerce website competiveness index evaluation index system. The competiveness level of the website is quantified after calculating the competiveness index of the E-commerce website. On this basis, this work adopted Radial Basis Function (RBF) neural network algorithm to perform evaluation research on the competiveness index of E-commerce website. Aiming at the problems exist in the evaluation research, this work tried to use Fruit Fly Optimization Algorithm (FOA) to perform improvement on the RBF neural network algorithm. Through the simulation and comparison of practical examples, FOA-RBF algorithm is obviously better than RBF neural network algorithm when the E-commerce website competiveness index is calculated and evaluated, thus the validity and reliability of calculating method presented in this work are verified.

Keywords: e-commerce, neural network, radial basis function, fruit fly optimization algorithm, expert grading method

1 Introduction

In recent years E-commerce has obtained fast development, and competition is also becoming increasingly fierce. For E-commerce website, its own competitive power is sufficiently evaluated and understood, which is favourable to strengthen website construction and improve the quality of the website; the premise for enterprises to improve competiveness level and obtain competitive advantage; a problem [1] which needs to be solved urgently.

2 Evaluation research on the competitiveness index of E-commerce website

2.1 TYPES OF E-COMMERCE WEBSITE

The E-commerce website can be divided into different types [2] by different classification methods.

1) Classified according to commercial purpose and business function

- Basic commerce website.

For the basic commerce website, the company publicity and customer service are performed by means of basic measures in network media and E-commerce. This kind of website is appropriate for small enterprises with weak power of professionals and in need of E-commerce service. Its characteristics are cheap price of website construction, and high performance cost ratio.

- Publicity commerce website.

Website can be served as the important window of enterprises' public relationship, which is used to publicize the latest news and the business condition of the enterprises. This kind of website is mainly served for some listed companies at home and abroad, on the official websites of which the columns of company news and introduction of the investors are established, becoming the official channel for enterprises to publish news and source rule. The publicity commerce website is appropriate for all kinds of enterprises, especially for the foreign trade enterprises.

- Customer-oriented service website.

This kind of website can provide the inquiry of the after-sale service and the dynamic service status, satisfying the customer demands at a higher level.

- Complete E-commerce operation website.

Complete E-commerce operation website refers to various aspects of E-commerce, such as the distribution management, online shopping and online recruitment. This kind of website can be more clearly described as a set of business management system software.

2) Classified according to the principal part of constructing a website

- Industry E-commerce website.

Industry E-commerce website means a large-scale E-commerce website constructed with the industry organization as the principal part, providing a platform of information distribution, commodity order and customer communication for enterprises and departments in the Industry to perform E-commerce.

- Enterprise E-commerce.

Enterprise E-commerce means that the website is constructed with the enterprises as the principal part to implement E-commerce activities, and can be further divided

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into variously different types of websites according to the leading products of enterprises and the different services provided.

- Government E-commerce website.

Government E-commerce website means the website is constructed with the government body as the principal part to implement E-commerce activities.

- Service organization E-commerce website.

Service organization E-commerce website means the website is constructed with the service organization as the principal part to implement E-commerce activities.

3) Classified according to the responsibilities of the website owners

- Production commerce website.
- Circulation commerce website.

4) Classified according to E-commerce model.

- B2B commerce website.
- B2C commerce website.
- C2C commerce website.
- G2C commerce website.

2.2 COMPETIVENESS INDEX OF E-COMMERCE WEBSITE

Whatever kinds of E-commerce websites, the dominant factors affecting its operation effects and competitive power, are basically the same. The overall level of the E-commerce website is decided by the combined effect of these factors, producing great influence on the function realization of the website and making the E-commerce website present different competitive power. Therefore, the competiveness index of E-commerce website is proposed to measure E-commerce website in competition, reflecting the level of the website in design operation [3].

Aiming at the development status and characteristics of E-commerce website, this work performed research on the competiveness index of E-commerce website according to the principles of comprehensiveness, scientific, operability, industry representativeness and taking content as the core. On basis of performing in-depth investigation and research on the currently famous E-commerce websites as well as learning the research achievements of other scholars and some organizations [4], the more optimized algorithm is used to simulate and calculate the competiveness index of an E-commerce website.

2.3 INDEX SYSTEM OF E-COMMERCE WEBSITE COMPETIVENESS INDEX MEASUREMENT

Through relatively specific literature research, the evaluation index system of E-commerce website competiveness index is established by adopting comprehensive evaluation method during the process of performing measurement on E-commerce website competiveness index. Twenty representative secondary indexes are finally selected as the evaluation object after performing investtigation analysis and literature learning on lots of E-commerce websites. The finally-designed index system includes the first class index and the secondary index, therein to, the first class index includes five indexes - website content, user service, usability, website technology and website function, and the five first class indexes are subdivided on this basis to constitute the secondary evaluation index [5].

3 RBF neural network algorithm

3.1 CONCEPT OF RBF NEURAL NETWORK ALGORITHM

Artificial neural network is applied successfully in many fields by means of its unique information processing capacity. It not only possesses powerful nonlinear mapping capacity, but also obtains the characteristics of self-adaption, self-learning and fault tolerance, clustering and learning from lots of historical data so as to find the change law of some behaviour. Radial basis function (RBF) is a kind of fresh and valid forward feedback neural network [6], with the property of the best approximation and global optimum. Meanwhile, the training method is quickly and easily to be implemented, and there is no problem of local optimum. These advantages make RBF network broadly applied in nonlinear time series prediction. In 1985 Powell presented the Radial-Basis Function (RBF) method of multivariate interpolation [7]. In 1988 Broomhead and Lowe firstly applied RBF to neural website design, constituting the RBF neural network [8].

3.2 COMPOSITION OF RBF NEURAL NETWORK

The most basic composition of RBF neural network includes three layers – input layer, hidden layer (middle layer) and output layer. Therein to, the input layer is composed of some source points (perception units), which connect the network with the external environment, with the transmit function of data information and no transformation on the input information; the kernel function (or action function) of the hidden layer neuron is adopted as the RBF, which performs nonlinear transformation between the input information and the space of the hidden layer, and the higher dimensionality is usually obtained; the output layer is linear provides response for the activation pattern of the input layer.

Setting the neurons of the hidden layer and the output layer as M and Q, respectively, the input pattern is noted as X, and $X=[x_1,x_2,\cdots,x_R]^T$; the output pattern is noted as Y, and $Y=[y_1,y_2,\cdots,y_Q]^T$. The RBF in this work is Gauss function, so the output of the hidden unit is [9]:

$$z_j=\exp\left(-\left\|\frac{X-C_j}{\sigma_j}\right\|^2\right),\ j=1,2,\cdots,M\ , \tag{1}$$

where z_j is the output value of the j neuron in hidden layer; C_j is the center of the j neuron of the hidden layer, composed by the j neuron of the hidden layer corresponding to the center component of all neurons in the input layer, and $C_j = \left[c_{j1}, c_{j2}, \cdots, c_{jR}\right]^T$; σ_j is the width of the j neuron of the hidden layer, corresponding to C_j; $\|\bullet\|$ is Euclid Norm.

The in-out relational expression of the neurons in output layer is:

$$y_k = \sum_{j=1}^{M} w_{kj} z_j \qquad k = 1, 2, \cdots, Q, \tag{2}$$

where y_k is the output value of the j neuron of the output layer; w_{kj} is the weight between the k neuron of the output layer and the j neuron of the hidden layer.

The parameter of the RBF neuron network hereby mainly means the center, width of the network and the adjust weight [10].

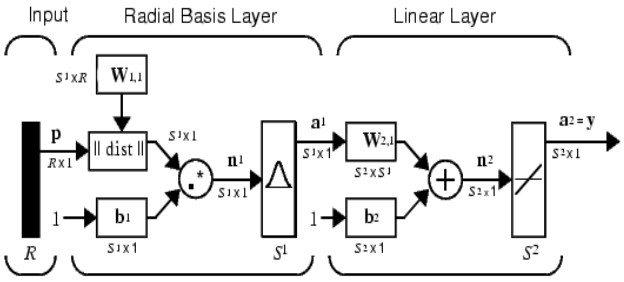

FIGURE 1 RBF neuron network structure

4 Competitiveness index evaluation of E-commerce website based on RBF neuron network algorithm

4.1 ANALYTIC HIERARCHY PROCESS

Analytic Hierarchy Process (AHP) is a kind of hierarchical and structuralized decision analysis method of qualitative and quantitative combination, proposed by American operational research expert T.L.Saaty in 1970s [11]. This method is the most representative comprehensive evaluation method where the factor aggregation is hierarchical, the hierarchical structure model composed, and then the analysis performed by layers according to the interrelationship between factors on the basis of the nature of problems and the component elements of the goal decomposition problems; the weight of various factors is established according to the comparison between factors, appropriate for the decision problems with multiple targets and attribution. It's concise and effective, with extensive practicability.

4.2 DETERMINATION OF RBF NEURAL NETWORK INPUT AND OUTPUT

The method of RBF neural network is adopted to perform measurement and evaluation on the competitiveness index of E-commerce website, and the determination of target output is critical for RBF neural network. Because RBF neural network belongs to supervised learning, a group of expected output data is required as the reference for learning. Therefore, various indexes of E-commerce website competitiveness index should be scored if the target output would be determined.

Expert grading method is a common method, analytic hierarchy process is applied in this work to calculate the weight of various indexes by means of expert grading method, and then the evaluation index system of E-commerce website competitiveness index is used to perform measurement and evaluation on the E-commerce website competitiveness index, evaluating the quality and competitiveness level of E-commerce website [12].

The method of combining expert interview with questionnaire survey is adopted in expert grading method, which can effectively guarantee the objectivity and validity of the obtained data.

The marking rules are as follows: the 20 secondary indexes in the evaluation index system of E-commerce service website are served as the RBF neural network input to perform evaluation on the website (Table 1). The index of each website is scored by experts, and then the quantitative analysis is performed on the results to quantize each evaluation index [13].

TABLE 1 Score list of website evaluation index system

The first class index	The secondary index	Better (score)	Medium (score)	Worse (score)	Scoring methods
A1 Website content	B1 Timeliness	6	4	2	Monitoring method
	B2 Accuracy	6	4	2	Investigation method
	B3 Professional	5	3	1	Investigation method
	B4 Authority	5	3	1	Investigation method
A2 User service	B5 Personalized service	6	4	2	Investigation method
	B6 Protection of user privacy	5	3	1	Investigation method
	B7 Credit monitoring of transaction norm	4	2	0	Investigation method

	B8 Expert technical support	4	2	0	Investigation method
	B9 Website customer service	5	3	1	Investigation method
	B10 User interaction	4	2	0	Investigation method
A3 Usability	B11 Site map	5	3	1	Investigation method
	B12 Website design	5	3	1	Investigation method
	B13 Classification of website information	5	3	1	Investigation method
A4 Web technology	B14 Search function	5	3	1	Investigation method
	B15 Validity of links	5	3	1	Test method
	B16 Browser compatibility	5	3	1	Test method
	B17Website security	5	3	1	Test method
A5 Website operation	B18 Website traffic	5	3	1	Monitoring method
	B19 Quantity of the linked	5	3	1	Monitoring method
	B20 User number of the website	5	3	1	Monitoring method
	Total	100	60	20	

4.3 APPLICATION OF ANALYTIC HIERARCHY PROCESS IN INDEX SYSTEM

What we should urgently solve and determine is that the "contribution degree"---weight of various secondary indexes in the website competitiveness evaluation after the evaluated first class index and various secondary indexes are determined. The analytical hierarch process can be adopted to perform index weight evaluation on the first class index and secondary index in order to determine the weight. And the specific operation steps are that the user survey and data analysis should be firstly performed, the judgment matrix of different levels of indexes are established after the indexes at the same layer are compared pairwise (the comparison of importance degree and non-importance degree), the weight of various indexes and their characteristic root can be obtained after calculation by means of AHP method, the consistency test should be performed on the above results, and the satisfying consistency can be recognized until CR<0.10. The judgment matrix at each layer of index is established in this work according to the steps of analytic hierarchy process, the relative weight value of each layer index could be obtainned by calculation, and then the weight of various indexes of E-commerce website competitiveness evaluation index are obtained by consistency test, thus a complete evaluation index system [14] which is appropriate for E-commerce website competitiveness is finally constructed.

4.4 DETERMINATION STEPS OF EVALUATION INDEX SYSTEM WEIGHT

4.4.1 Establishment of judgment matrix

Generally speaking, users express different attention on the characteristics at various aspects of the website, someone pay more attention to the content elements of the website, and someone place extra emphasis on the obtained service and feelings. For this purpose, the result of expert grading is applied to establish the judgment matrix. The specific operation are as follows: aiming at each index (including the first class index and secondary index), five importance grades are established, which respectively are the most important, very important, important, more important and generally important. The score for the most important is $K_1 = 5$, followed by $K_2 = 4$, $K_2 = 4$, $K_4 = 2$ and $K_4 = 2$. Thus the calculation Equation of the importance score for each index is [15]:

$$M = \sum_{n=1}^{5} P_n g K_n ,$$

where P_1, P_2, P_3, P_4 and P_5 respectively represent the ratio in the overall number of people, aiming at each index and the people who choose different importance grades.

4.4.2 The judgment matrix is determined by scores

Calculation steps are as follows:

1) Calculating the product of the elements in each row of judgment matrix, the Equation is:

$$L_i = \prod_{j=1}^{n} a_{ij} \qquad (i = 1, 2, ..., n)$$

2) Calculating L_i to the N[th] root value in each row, the j is:

$$K_i = \sqrt[n]{L_i} .$$

3) The vector $K = (K_1, K_2, K_3, K_4, K_5)^T$ is performed by normalization processing, $w = K_i \Big/ \sum_{\wedge j=1}^{n} K_j$ (w is the index weight at each level).

Accordingly, the weight of each secondary index in the affiliated level can be calculated. Table 2 shows the calculation result.

TABLE2 Weight of secondary index in the affiliated level

Secondary index	*w*	Secondary index	*w*	Secondary index	*w*
B1	0.4	B8	0.107	B15	0.177
B2	0.4	B9	0.055	B16	0.315
B3	0.2	B10	0.328	B17	0.061
B4	0.247	B11	0.150	B18	0.168
B5	0.113	B12	0.068	B19	0.397
B6	0.247	B13	0.454	B20	0.051
B7	0.231	B14	0.447	-	-

The website with higher scores indicates that the comprehensive quality of the website is better. It's divided into 5 grades which are excellent, good, better, worse and very bad. The score explanation at each grade refers to Table 3.

TABLE 3 Score explanation of website evaluation grades

Grade	Score
Excellent	0.9score and above
Good	0. 75-0. 89 score
Better	0. 65-0. 74 score
Worse	0. 55-0. 64 score
Very bad	0.54score and below

4.5 RBF NEURAL NETWORK ALGORITHM ADOPTED TO CALCULATE THE COMPETITIVENESS INDEX OF E-COMMERCE WEBSITE

The order of adopting RBF neural network to perform evaluation on the website is: firstly, the data of evaluation index system of E-commerce competitiveness index which have been established serve as the input sample, and a RBF neural network model is established to performing training on internet; secondly, test is performed on the established evaluation network model according to the results of training and learning; finally, conclusion and analysis should be performed on the results of website learning and training. From March to June in 2013, the competitiveness index of 100 designated E-commerce websites is scored by means of expert grading method, and the uniform treatment is performed on the obtained data. The front 70 groups of data are used to test, and test is performed on the rear 30 groups of data. The parameter of the RBF neural network is set as: the error goal=0.0001, spread=1, the maximum quantity of the neurons at the hidden layer is mn=20, and the displayed frequency in the training process df=1. The training results are shown in Figure 1:

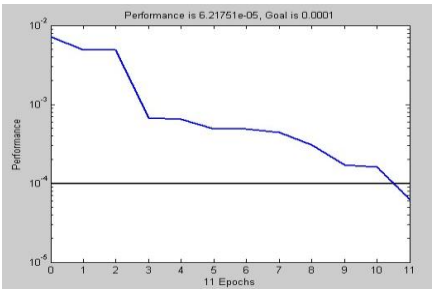

FIGURE 1 Training process figure of RBF neural network

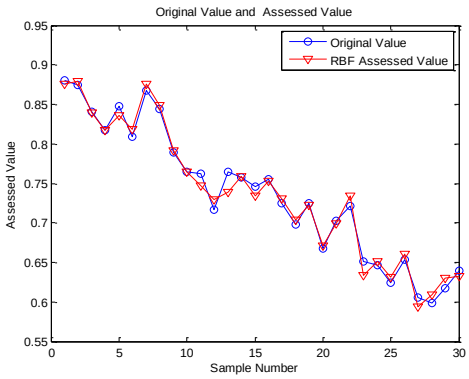

FIGURE 2 Comparison figure of the RBF predicted result and the original value

It can be found that the E-commerce evaluation result of applying RBF neural network is better, and the evaluated absolute error figure and relative error figure are shown in Figure 3 and Figure 4, respectively.

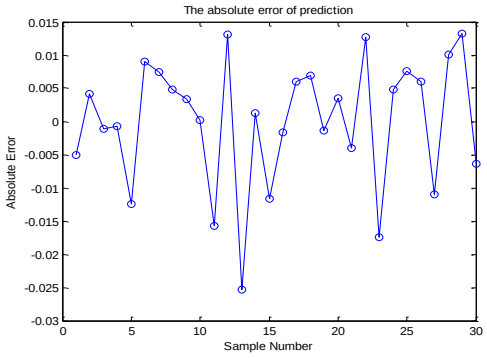

FIGURE 3 Absolute error figure predicted by RBF

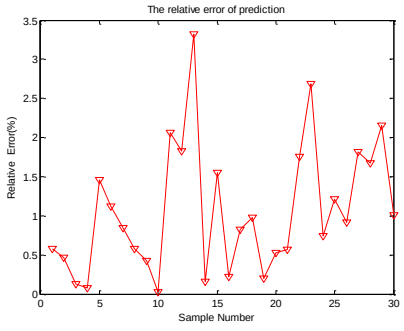

FIGURE 4 Relative error figure predicted by RBF

Figure 4 shows the average value of relative error in E-commerce website evaluation is at 2.5% by adopting

RBF neural network, with the better effect; but the problems of long time evaluation and excessive error in some evaluation points exist

5 Fruit fly algorithm optimization RBF neural network model

5.1 BRIEF INTRODUCTION OF FRUIT FLY OPTIMIZATION ALGORITHM

Fruit Fly Optimization Algorithm (FOA) was a kind of brand new evolutionary computation method presented by Taiwan young teacher Pan Wenchao [5-8] in 2011. Because the fruit fly is superior in the sense of smell and sight, which is shown in Figure 5. Fruit fly searches the food source in air; its keen sense of sight is used to find food and the position where its companions gather after finding food, and finally fly to the position. Therefore, this method considers that fruit fly searches food, it firstly searches the approximate position of the food by smell and then confirms the correct position of the food by sight. This method is a new method of seeking global optimization based on the foraging behavior of fruit fly.

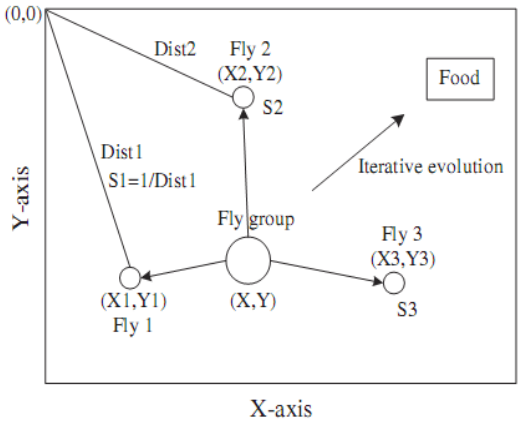

FIGURE 5 Iteration food search figure of fruit fly group

5.2 STEPS OF FRUIT FLY OPTIMIZATION ALGORITHM

The fruit fly optimization algorithm can be divided into seven steps as follows [9]:

1) Figure 5 shows the initialization of the fruit fly group position, and the result of initialization is Init X_axis; Init Y_axis;

2) When the search direction RV_x and RV_x is set, random search distance of the individual fruit fly can be obtained by the following formula:

$$\begin{aligned} Xi &= Init\ X\_axis + RV_x \\ Yi &= Init\ Y\_axis + RV_y \end{aligned} . \tag{3}$$

3) Because the position of the food is unknown, therefore the distance Disti between the current position of individual fruit fly and the original point needs to be evaluated. The decision value Si of taste and consistency can be calculated after that, the decision value of taste and consistency equals to the reciprocal of the distance.

$$\begin{aligned} Disti &= \sqrt{Xi^2 + Yi^2} \\ Si &= 1/Disti \end{aligned} . \tag{4}$$

4) Taste and consistency decision value is substituted into taste consistency to judge the function and calculate the taste consistency of the individual fly's current position.

$$Smelli = Function(Si) . \tag{5}$$

5) The best taste consistency in fruit fly group can be obtained by the following formula:

$$[bestSmell\ bestIndex] = \max(Smelli) .$$

6) Preserve the best taste consistency value of fruit fly group and its corresponding x-coordinate and y-coordinate, then the fruit fly group performs positioning on the food source by means of personal sight, and fly to the position of the food source after that.

$$\begin{aligned} Smellbest &= bestSmell \\ X\_axis &= X(bestIndex) . \\ Y\_axis &= Y(bestIndex) \end{aligned}$$

7) Entering iterative optimization, repeat the iteration steps 2-5, and meanwhile judge if the taste consistency is better than the previous iterative taste and consistency; if it's established, the step 6 shall be performed.

5.3 MODEL OF FRUIT FLY ALGORITHM RBF NEURAL NETWORK

This work uses MATLAB neural network tool box RBF neural network function to establish improved RBF neural evaluation model [16] of fruit fly optimization algorithm. The spreading parameter Spread of RBF neural network is mainly optimized, the bigger the Spread is, the more smooth the function matching is. But the excessive Spread means to require lots of neurons to adapt to the rapid change of function. If the Spread is undersize, which means more neurons are required to be fit to the slow change of the function, thus the website performance is worse.

In the past different Spread values are tried to determine the optimum value during the design process of RBF, thus lots of time will be spent, and meanwhile the best of the determined Spread value can't be guaranteed.

FOA algorithm in this work is adopted to search the optimum value within the whole situation, the predicted error sum of squares and served as the taste judgment function to determine the optimum RBF spreading parameter Spread. The specific steps of algorithm are as follows:

1) Confirming the number of individuals and the maximum iteration times in the group, and meanwhile the initial position of the fruit fly can be generated randomly;
2) Endowing the random flight direction and distance section [-1 1] for fruit fly individual to search food.
3) Estimating the distance between the original point, calculating the taste and consistency judge value, which is the spreading parameter Spread, if the spreading parameter Spread <0.01, thus the Spread=1.
4) Taking Spread into the RBF to perform network training and simulation, the function shall be judged by the predicted error squares and as the taste, the taste and consistency of the fruit fly position can be obtained, which is the error sum of squares.
5) The optimum taste and consistency in the fruit fly group, which means, the fruit fly with the lowest taste consistency make the error sum of squares the lowest.
6) Preserving the optimum spread parameter Spread and its corresponding x-coordinate and y-coordinate, meanwhile the fruit fly group performs positioning on food source by means of own sight, and then fly to the position where the food source exists.
7) Entering the iterative optimization, repeating iterative steps 2-5, meanwhile judging if the taste consistency is better than the previous iterative taste consistency; if it's successful, the step 6 will be performed.

6 E-commerce website competitiveness index is calculated based on the fruit fly optimization RBF neural network algorithm

Set the parameter of fruit fly optimization algorithm, the number of iterations is 100, the population size is 30. MATLAB is applied to solve by programming, and the solved result are as follows:

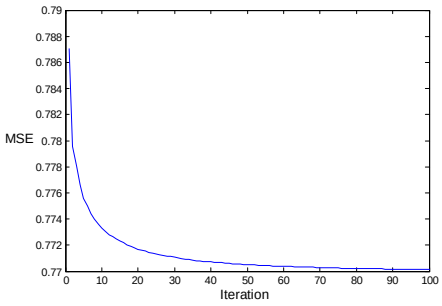

FIGURE 6 The square error convergence map of fruit fly optimization algorithm RBF

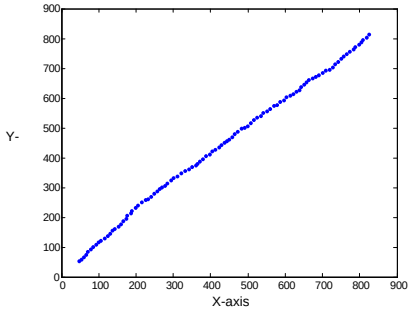

FIGURE 7 Optimization path of fruit fly algorithm

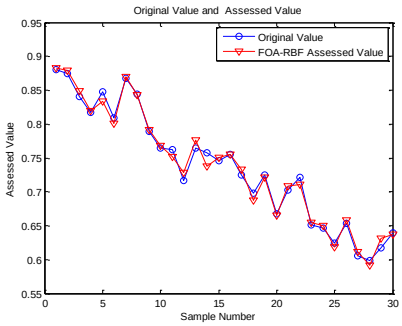

FIGURE 8 Comparison figure of FOA-RBF predicted result and the original value

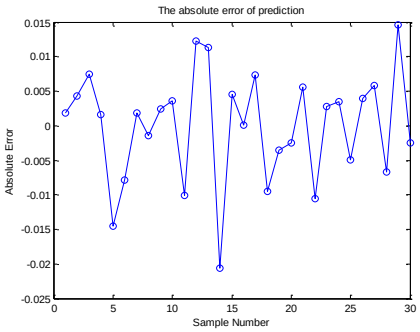

FIGURE 9 FOA-RBF predicted absolute error figure

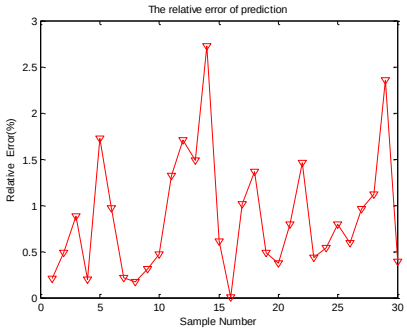

FIGURE 10 FOA-RBF predicted relative error figure

The simulated result of FOA-RBF algorithm shows that the prediction accuracy of FOA-RBF algorithm is higher than the RBF neural network algorithm, and the expected absolute error and relative error are shown in Figure 9 and Figure 10. The optimizing rate of convergence is faster in FOA-RBF algorithm, with good convergence. The characte-

ristic of convergence is shown in Figure 6, and the optimazing path of fruit fly in 2-D space in Figure 7.

7 Conclusions

The expert grading method is used to construct a multi-index hierarchical structure of E-commerce website competitiveness evaluation, with the establishment of an E-commerce website competitiveness evaluation index system, and thus quantizing the competitive level of the website. After that, RBF neural network algorithm is used to perform evaluation research on E-commerce website, aiming at the problems exist in evaluation research, fruit fly optimization algorithm is applied to perform improvement on RBF neural network algorithm. It can be seen by means of simulated comparison of the practical examples, FOA-RBF algorithm is obviously better than RBF neural network algorithm on evaluating the accuracy and processing time of E-commerce website, thus the validity and reliability of the algorithm in this work are verified, and this method can be promoted to other fields so as to easily solve other similar problems.

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