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Research Article

Research on Evaluation Indicator System and Methods of Food Network Marketing Performance

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Abstract: The research on network marketing performance evaluation, including evaluation indicator system and methods, lies in the core status in marketing performance management system. A new evaluation indicator system and wavelet BP neural network algorithm are presented to evaluate food network marketing performance. First, the evaluation indicator system of food network marketing performance is constructed based on analyzing the unique characteristics of food network marketing performance; Second, the wavelet BP algorithm is designed, then genetic algorithm is used and the calculation flows of the new algorithm are redesigned to improve the convergence speed of wavelet BP neural network algorithm; Finally, the presented evaluation indicator system and algorithm are realized to evaluate network marketing performance of three food network enterprises and the evaluation results show that that the algorithm can improve calculation efficiency and evaluation accuracy when used practically and can be used for evaluating other complicated systems also.

Keywords: BP neural network algorithm, food network marketing performance evaluation, genetic algorithm, marketing performance management, wavelet

INTRODUCTION

As a new pattern of marketing, network marketing is becoming a mainstream marketing in all walks of life. Both the rapid development of the food industry and network marketing jointly promotes the extensive application of food network marketing and network marketing has gradually become the focus of the food marketing in new century. But as an indispensable component of marketing management, performance evaluation needs future consideration and improvement in evaluation indicator system and methods design in application of food network marketing, so the research on evaluation indicator system and methods for food network marketing has become a hot topic for the researchers related and food enterprises (Toher and Sette, 2011).

Up to now, mathematical models adopted by evaluating network marketing performance mainly include the following categories:

- Analytic hierarchy process is a good method for quantitative evaluation via quantitative method, having the functions of establishing the ideal weight structure of evaluated object value and analyzing the weight structure of actually-built value by evaluated object; however, the method has strong limitations and subjectivity, with large personal error, not suitable for complicated system with lots of evaluation indicators (Yueh, 2013).
- Fuzzy comprehensive evaluation is a method carrying out comprehensive evaluation and decision on system through fuzzy set theory, the greatest advantage of which is that it works well on system evaluation of multi-factor and multi-level complicated problems. However, the membership of fuzzy evaluation method as well as the definition and calculation of membership function are too absolute, difficult to reflect the dynamics and intermediate transitivity of evaluation indicators of English course education performance (Ya and Janst, 2012; Gandha and Bartlett, 2011).
- BP neural network evaluation method makes use of its strong capability in processing nonlinear problems to carry out evaluation of English course education performance; the method has advantages like self-learning, strong fault tolerance and adaptability; however, the algorithm is easy to be trapped into defects like local minimum, over-learning, strong operation specialization (Thompson, 2012; Rian and Merve, 2013).

Taking advantage of the positive effects of BP algorithm, the paper overcomes the negative effects of original BP algorithm based on the wavelet algorithm to improve the working principle of ordinary BP neural

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network algorithm to present a new wavelet BPNN algorithm for evaluating food network marketing performance.

MATERIALS AND METHODS

Evaluation indicator system construction: Evaluation indicator system construction is the first key step for evaluating network marketing performance correctly and effectively, so does the food network marketing performance evaluation. And the indicator system for evaluating network marketing performance is constituted of multiple elements and is a complex, dynamic, timely comprehensive system, in which various subsystems and indicators coexist in different forms. Base on analyzing the unique characteristics of food network marketing performance, combined with literatures and experts consultations (Toher and Sette, 2011; Yueh, 2013) and according to connotation characteristics of common network marketing performance evaluation. This study constructs a scientific and wide evaluation indicator system for evaluating food network marketing performance and the system includes 3 hierarchies, 3 categories, 3 first-grade indicator, 9 second-grade indicator, 24 third-grade indicator (Table 1).

Designing wavelet BP neural network algorithm: The algorithm structure and expression of wavelet neural network and BP neural network are always the same, which consist of input layer, hidden layer and out layer. The key difference of the two algorithm is that wavelet neural network takes wavelet transformation function as its excitation function and that of BP neural network is Sigmoid function. The working principle of wavelet neural network model is that it changes waveform and the scale of wavelet bases continuously to adjust the weights and threshold of the network taking advantage of the principle of minimum error function. The topological structure of wavelet neural network model can be seen in Fig. 1 (Sue and Raman, 2010; Shih, 2013).

f'(i) means the i^{th} input and O_k means the k^{th} output of wavelet neural and network model, respectively and y (j) means the j^{th} output of wavelet layer, in the above equation $i = (1,2,...,input)$, $j = (1,2,...,hidden)$, $k = (1,2,...,output)$, w_{ij} is the connection weights between the i^{th} input and the j^{th} wavelet element. And v_{jk} is the connection weights between the j^{th} wavelet element and k^{th} wavelet layer, M_j is the j^{th} corresponding sliding scale of wavelet neural and network model, L_j is the j^{th} corresponding contraction coefficient, F means wavelet function, Φ means the function of output layer. Following are the relation between input and output of different layers.

The relation between input and output in the wavelet layer can be seen as Eq. (1) and (2) (Sue and Raman, 2010):

$$net_j = \sum_{i=1}^{input} v_{ij} f'(i), \qquad j = 1,2,...,Input \tag{1}$$

$$y(j) = F(f'(net_j)), \qquad j = 1,2,...,Input \tag{2}$$

The relation between input and output in the output layer can be seen as Eq. (3) and (4):

$$net_k = \sum_{i=1}^{Hiddenoutput} w_{jk} y_j \qquad j = 1,2,...,Hidden \tag{3}$$

Table 1: Evaluation indicator system for food network marketing performance

Target hierarchy	First-class indicator	Second-class indicator	Third-class indicator
Performance of food network marketing	Website performance side	Website design	Domain name choice
			Style and visual effects
			Retrieval function
			Information update frequency
		Website properties	Safety
			Functional comprehensive
			Download speed
			Link availability
			Interactive convenience with users
		Website popularization	Effects of search engine promotion
			Effect of network advertisement
		Website flow	The number of visitors
			The average number of page views
			Flow conversion rate
	Enterprise performance side	Financial performance	Sales revenue growth rate
			Sales profit growth rate
		Competition performance	Brand awareness
			Market share growth
			Consumer permeability
	Customer performance side	Customer service	Service response speed
			Problem solving efficiency
		Customer satisfaction	Customer feedback evaluation
		Food logistics distribution	Received the integrity of goods
			The speed of food receipt

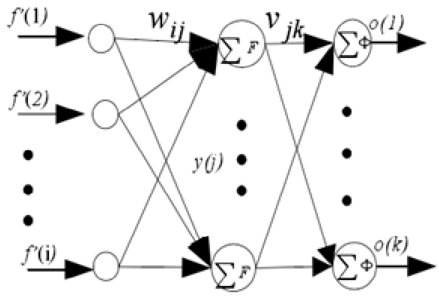

Fig. 1: The topological structure of the improved algorithm

$$y(j) = \Phi(f'(net_j)), \qquad j = 1,2,..., Hidden \tag{4}$$

From Eq. (3) and (4), it can get the relation model between input and output of wavelet neural network easily, like Eq. (5):

$$O = \Phi(\sum_{j=1}^{Hidden} v_j F((\sum_{i=1}^{Input} w_{ij} f(i) - M_j) / L_j \tag{5}$$

Improving wavelet neural network algorithm with genetic algorithm:

Chromosomes expression and initial population generation: The training process of neural network is the process of determining the weights, there sholds and telescopic translation operators, so it should takes weights *IW*, *LW* and threshold b_1, b_2 and telescopic translation operators *a*, *b* as decision variables in training neural network with genetic algorithm and then makes decision variables as a letter string and takes it as a solution to the problem. The algorithm uses real number encoding, the string is as follows. $IW_{11}, IW_{12},..., IW_{ji},..., IW_{JI}$, $LW_{11}, LW_{12},...,..., LW_{KJ}$, $a_1, a_2,...,$, $b_1, b_2,..., b_J$, $b1_J$, $b2_1, b2_2,..., b2_k$. In which IW_{ji} means the connection weights between the i^{th} neuron in input layer and the j^{th} neuron in hidden layer, LW_{kj} means the connection weights between the j^{th} neuron in hidden layer and the k^{th} neuron in output layer, a_J means the expansion and contraction parameters of the j^{th} neuron, b_J means the translation parameters of the j^{th} neuron, $b1_J$ means the threshold of the j^{th} neuron and $b2_k$ means the threshold of the k^{th} neuron in output layer.

Initial population process includes determining population size, cross probability and specifying a random value interval of *IW* and *LW* of each genes and then generates a new gene.

Target function and fitness function: Genetic algorithm only can be evolved along with the increase direction of fitness function increase value, so the fitness function can be designs as reciprocal form of object function, see as Eq. (6) and (7):

$$fit(i) = 1 / E(i) \tag{6}$$

$$E(i) = \frac{1}{2p} \sum_{p=1}^{p} \sum_{k=1}^{K} (d_k^p - a2_k^p) \tag{7}$$

In which, d^p_k means target output and $a2^p_k$ means the actual output of network.

Evolution computation: Evolution computation is conducted through selecting operator and is a process of population generational renewal. Using fitness of each chromosome, the algorithm selects the chromosome of next generation from population based on sampling mechanism of fixed selection probability. The evaluation tendency of the population is decided by the characteristics of selection operator which is always be described through three aspects of sampling space, sampling mechanism and selection probability.

Genetic computation: Genetic computation includes cross operation and mutation operation. And cross operation conducted here occurred in the same loci of different two chromosomes, not means the concrete chromosomes. Cross operation rate means the ration of genes involve in crossover operation to total numbers of genes. Weights value breaks the value space of initial weights though mutation operation and searches toward a more extensive space.

Improving adaptive method of pheromone evaporation intensity *ρ*: Pheromone evaporation intensity ρ can affect the global search performance of genetic algorithm directly. If ρ value is too small, the cumulative pheromone intensity in the selected road will be too large and easy to early-maturing and If ρ value is too large, the cumulative pheromone intensity in the unselected road will be evaporated and will be become small and that makes global search performance of genetic algorithm decreased. If the ρ has no improvement after many circulation calculation times, Eq. (8) can be taken as adaptive method of Pheromone evaporation intensity ρ:

$$\rho(t+1) = \begin{cases} \exp(-\alpha)\rho(t), & if \exp(-\alpha)\rho(t) \succ \rho_{\min} \\ \rho_{\min} & else \end{cases} \tag{8}$$

According to experiment test, it will has preferable calculation effects when the value of α lies in the space of (0.0001, 0.001). The value of $\rho_{\min}$ cannot be too small also and take it equal to 0.2 in the study.

In order to highlight the mechanism that how the optimal solution of last generation attract the next generation, the next generation of attractive highlight on the generation of optimal solution, Eq. (9) can be used to update pheromone:

$$\tau(G_{wi}) = (1-\rho)\tau_j(G_{wi}) + \sum_{1}^{num} \Delta\tau_j(G_{wi}) \tag{9}$$

Table 2: Part evaluation results of different network enterprises

	Website performance	Enterprise performance	Customer relationship	Final evaluation
Corporation A	3.017	3.298	3.641	3.234
Corporation B	3.471	3.901	4.279	3.803
Corporation C	4.002	4.508	4.793	4.408

Table 3: Evaluation performance comparison of different algorithms

Algorithm	Algorithm in the study	Ordinary BP algorithm	Fuzzy evaluation algorithm
Accuracy rate	93.98%	83.98%	69.28%
Time consuming (sec)	11	561	11

In which only *num* ants find their optimal solution and the global pheromone can be updated by these *num* num ants; $\sum_1^{num} \Delta\tau_j\ (G_{wi})$ means the pheromone summary of the ants that got their optimal solution in this circulation calculation (Wettler, 2012; Tuffer and Wooder, 2011).

Improving the convergence speed of the algorithm: BFGS (Broyden, Fletcher, Goldfarb and Shanno) algorithm is a very effective optimization algorithm, especially its superiorities in solving high dimensional optimization problems compared with gradient descent methods. So the paper uses BFGS algorithm to improve the speed up convergence speed of original wavelet neural network algorithm and remedies the disadvantages of too long search time of original genetic algorithm. The paper takes relative average output error equation of wavelet neural network as objective function, suppose $W(w_1, w_2, ...)^T$ as weight vector of wavelet neural network, its updating equations can be seen as Eq. (10) to (12):

$$H^{k+1} = H^k + (\mu^k \Delta W^k (\Delta W^k)^T - H^k \Delta G^k (\Delta W^k)^T - \Delta W^k (\Delta W^k)^T H^k) / \Delta G^k (\Delta W^k)^T \quad (10)$$

$$W^{k+1} = W^k - \beta H^k \nabla E_{RR}(W^k) \quad (11)$$

$$\mu^k = 1 + (\Delta G^k)^T H^k \Delta G^k / ((\Delta H^k)^T \Delta G^k) \quad (12)$$

In which, $\Delta W^k = W^{k+1} - W^k$, $\Delta G^k = \nabla E_{RR}(W^{k+1}) - \nabla E_{RR}(W^k)$, k means the number of training, suppose $P^k = H^k \nabla E_{RR}(W^k)$, β can be gotten by adaptive method and should satisfy the Eq. (13):

$$E_{RR}(W^k + \beta P^k) = \min_{\beta \geq 0} E_{RR}(W^k + \beta P^k) \quad (13)$$

RESULTS AND DISCUSSION

Taking experimental data 3 food network corporations to create experimental database, the three food network enterprises are called corporation A, B and C respectively. For customer part data, 300 consumers of each food network corporations are investigated and the results is taken as the database for training and experimental verification in the study, totally 900 consumers' data for experimental confirmation which come from practical visit and investigation. In order to make the selected data representatives, 300 consumers (100 consumers from each corporations) with more than one and half years network food buying experience, 300 consumers with one year food buying experience, 300 consumers (100 consumers from each corporations) with less than 1 year food buying experience.

In order to save paper space, here omits the intermediate evaluation results, only final comprehensive evaluation results and some secondary evaluation results and provided (Table 2).

As for the evaluation performance of the advanced algorithm, the ordinary BP neural network (Rian and Merve, 2013) and fuzzy evaluation (Gandha and Bartlett, 2011) are also realized in the paper and the evaluation performance of different algorithms can been seen in Table 3. In Table 3, evaluation results of different 3 food network enterprises are chosen and compared with artificial evaluation to calculate the evaluation accuracy. The indicators of the calculation platform can be listed as follows Intel i3 2120, 2 GB DDR3, AMD Radeon HD 7450 and 3.3 GHz CPU, C programming language environment and windows XP operating system.

CONCLUSION

At present evaluation of network marketing performance, especially for food network marketing performance evaluation, lies in the core status in marketing performance management system and is an effective way to guarantee network marketing performance for network trade enterprises. So the research on network marketing performance evaluation, including evaluation indicator system and methods has become a hot topic for the researcher related. Taking advantage of the positive effects of BPNN and wavelet algorithm, the paper overcomes the negative sides and constructs a new evaluation indicator system for evaluating food network marketing performance. The case study in the paper takes the data of three food network corporation as an example to illustrate the preferable evaluation effects of the presented evaluation indicator system and method.

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