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Evaluation of food logistics system based on generalized regression neural network

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ABSTRACT

This paper constructs a food logistics system evaluation model based on generalized regression neural network. It first establishes an evaluation index system for food logistics system and studies the standardization of relevant indexes; then it explores related theories of generalized regression neural network and establishes a food logistics system evaluation model based on generalized regression neural network; finally a fairly satisfying test result is acquired through numerical example examination. The test result shows: the evaluation model proves to be simple and practicable and is effective in evaluating food logistics system. This paper provides food producers with an effective tool to select evaluate and manage food logistics system.

Key words: Food logistics system; generalized regression neural network; index system; evaluation model

INTRODUCTION

In recent years, food safety incidences have happened frequently, bringing about a lot of adverse effects on the improvement of people's living standard and the development of national economy. It is true that food safety is more closely related to food manufacturing. However, the role of logistics cannot be ignored. Food safety incidents like "cabbage with formaldehyde", "Chinese chives with chalcanthite", and "ginger with dichlorvos" are all related to logistics.

The frequency of food safety incidents is a reflection of the flaws and drawbacks of China's food logistics system. Thus, it is highly important for food producers to select an adequate food logistics system. In order to achieve this goal, food producers must fully understand food logistics system. An accurate, comprehensive, quick, and systematic evaluation is one of the means to understand food logistics system. Traditional systematic evaluation methods are relatively better developed in solving the systematic evaluation problem with multi-attribute, such as Delphi method, analytic hierarchy process, and fuzzy comprehensive evaluation [1]. These methods are not flawless, though, for they are either subjective or one-sided or over-dependent on raw data [2]. Generalized Regression Neural Network (GRNN), is a kind of neural networks (NNs). GRNN, like other NNs, is non-linear and independent of subjective and objective factors. It also overcomes shortcoming of other NNs, like slow convergence rate, trapping into local optima easily, weak classification ability, and slow learning efficiency [3]. Therefore, this paper applies generalized regression neural network to evaluate and analyze food logistics system.

CONSTRUCTION OF EVALUATION SYSTEM FOR FOOD LOGISTICS SYSTEM

Construction of a scientific evaluation index system is the basis and premise of conducting systematic evaluation. CHEN Jinquan et al.[4], in their book Food Logistics, put forward that the evaluation indexes of food logistics system can be classified into quantitative indexes and qualitative indexes. Economic index, technique index, time index, and resource index make up the quantitative index. Moreover, CHEN also proposes the constituent elements of quantitative index. In studying qualitative indexes, this paper applies related knowledge of food logistics and systematics, brainstorming method and Delphi method to examine what factors influence the operation of food logistics system. Among which, factors with large influence over the operation of food logistics system are selected as the qualitative indexes.

Quantitative indexes are easily comprehensible in the index system. Qualitative indexes include: system stability reflects the continuous operating ability of food logistics system; system agility reflects the ability of food logistics system to respond to market changes; system extension reflects the extensibility and upgradability of food logistics system; social perception reflects how well the public know the food logistic system; social contribution reflects how much the food logistics system contributes to social development; social responsibility reflects how well a enterprise carries out social responsibility; system pollution reflects the pollution level of a system; system energy consumption reflects the energy consumption level of a system.

When quantitative and qualitative indexes of food logistics system are selected, these indexes are regarded as the inputs of generalized regression neural network and used to establish a generalized regression neural network analysis model. In the generalized regression neural network, the input levels consist of influencing factors and outputs levels consist of analysis outcomes of the system.

PROCESSING OF INDEXES AND DATA

Evaluation index system consists of quantitative index and qualitative index. In systematic evaluation and decision-making, one of the significant features is the heterogeneity between indexes. Simply treating the index value as the input value is unlikely to generate objective analytic and evaluation results [5]. So, before the evaluation, indexes must be normalized and converted into values between [0, 1].

Suppose we are evaluating a system with the above indexes; each index has a feature value; so the evaluation matrix is as follows:

$$X = \begin{bmatrix} X_{1,1} & \cdots & X_{1,m} \\ \vdots & \ddots & \vdots \\ X_{n,1} & \cdots & X_{n,m} \end{bmatrix} = (x_{ij})_{n*m} i = 1,2,\dots,n;\ j = 1,2,\dots,m \quad (1)$$

In formula (1), is the feature vector of the No.n index in the system.

In the evaluation index previously mentioned, there are quantitative index and qualitative index; quantitative index and qualitative index are further developed into efficiency index and cost index respectively. We process these indexes according to the following steps:

1)Quantitative index

①efficiency index,

$$Y_{ik} = \frac{x_{ik} - \min\{x_i\}}{\max(x_i) - \min\{x_i\}} \quad (2)$$

②cost index,

$$Y_{ik} = 1 - \frac{x_{ik} - \min\{x_i\}}{\max(x_i) - \min\{x_i\}} \quad (3)$$

2)Qualitative index

Qualitative index must be quantified before normalization. Having experts within the research field to score each index, namely the expert scoring method, is the most frequently used quantification method. Then carry out normalization according to formula 2 and 3.

GENERALIZED REGRESSION NEURAL NETWORK

GRNN is a new neural network proposed by Donald. F. Specht on the basis of neural network knowledge and mathematical statistics theory. GRNN is the integration of radial basis function (RBF) and linear function. Therefore, in terms of network structure, GRNN is similar to RBF. GRNN has been widely favored in structure analysis, system evaluation and activity forecasting since it was first proposed [6-8].

Refer to references for theoretical derivation and theoretical basis of GRNN [9], for this paper will not cover more here. GRNN is a branch of radial basis network and has similar network structure to radial basis network. GRNN has one linear input level, several radial basis hidden levels and one linear output level. Its network structure is shown in figure 1.

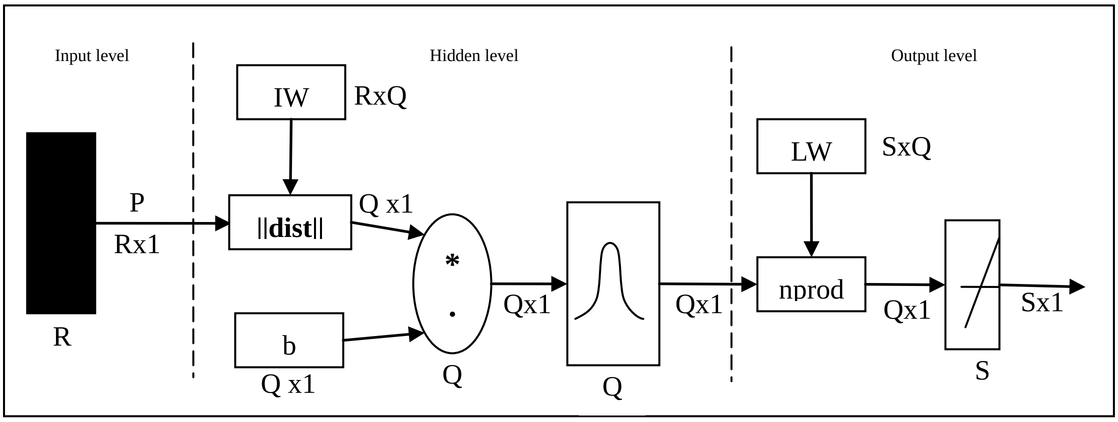

Figure 1.Structure of generalized regression neural network

In GRNN, the first level is a linear input level of variables, which transfers sample variables to hidden levels and does not involve in function operation. The second level is radial basis hidden level, which is responsible for handling calculation of variables; in the level, the number of neurons is the same as that of training samples; its weight function is a Euclidean distance function (expressed as ||dist||, see formula 4), which calculates the distance between the input level and the hidden level, or the threshold value of hidden level. The symbol for this value is "·". The transfer function of hidden level is usually a Gaussian function (see formula 5). Gaussian function has features of central projection and central bulge, which make the hidden level generate large output value when input is closer to the central range of basis function. It makes the algorithm has better local approximation ability and improves the learning speed of network.

$$||dist|| = || IW - P || = \sqrt{\sum_{i=1}^{R}(IW_t - P_t)^2} \quad (4)$$

$$R_i(x) = \exp\left(-\frac{||x - x_i||^2}{2\delta_i^2}\right) \quad (5)$$

The third level of network is linear output level. Its weight function is a normalized dot product function (expressed as "nprod" in figure 2), which is used in normalization of LW (see formula 6). The normalized result is sent to the linear transfer function (see formula 7). Output is calculated with this weight function.

$$n^2 = normp\ rod(LW_{2,1}, a^2) \quad (6)$$

$$a^2 = y = purelin(n^2) \quad (7)$$

Learning algorithm of GRNN is similar to that of radial basis neural network, except its output level. Learning algorithm of hidden level can be found in references [10]. Formula 8 and 9 are learning algorithm of output level.

$$n^i = normp\ rod\left(LW_{2,1}, a^i\right) = \frac{LW_{2,1} * a^i}{\sum_{j=1}^{Q} a_j^i} \ ; \ i = 1,2,\dots,Q \quad (8)$$

$$a^i = y = purelin(n^i) = n^i \ ; \ i = 1,2,\dots,Q \quad (9)$$

NUMERICAL EXAMPLE EXAMINATION

4.1 Data initialization

This numerical example has five food logistics systems as samples. Apply generalized neural network to evaluate these samples and to provide scientific basis for the selection, evaluation and management of food logistic system for food manufactures.

Input samples are shown in table 1; after normalization, the feature values of dimensionless indexes are shown in table 2; corresponding output samples are shown in table 3.

Table 1 initial index data of food logistics system

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
Sample 1	1300	88%	21%	96%	92%	97%	96%	89%	98%	5%	83%	100%
Sample 2	1459	79%	32%	89%	87%	93%	92%	92%	92%	7%	79%	96%
Sample 3	1331	81%	19%	93%	98%	100%	95%	87%	100%	11%	80%	99%
Sample 4	1287	90%	26%	100%	90%	96%	97%	96%	97%	4%	74%	93%
Sample 5	1378	87%	24%	95%	96%	99%	91%	90%	99%	12%	78%	96%
	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}	X_{21}	X_{22}	X_{23}	X_{24}
Sample 1	84%	86%	90%	92%	9	8	9	9	7	5	4	7
Sample 2	88%	91%	94%	87%	8	8	8	7	5	3	8	6
Sample 3	91%	93%	93%	96%	9	7	9	4	6	7	3	8
Sample 4	87%	90%	91%	90%	8	6	7	6	4	4	6	5
Sample 5	96%	85%	86%	92%	7	7	8	7	6	6	7	8

Table 2 dimensionless index feature value after normalization

	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}
Sample 1	0.08	0.82	0.85	0.36	0.45	0.57	0.83	0.22	0.75	0.13	1.00	1.00
Sample 2	1.00	0.00	0.00	1.00	0.00	0.00	0.17	0.56	0.00	0.38	0.56	0.43
Sample 3	0.26	0.18	1.00	0.63	1.00	1.00	0.67	0.00	1.00	0.88	0.67	0.86
Sample 4	0.00	1.00	0.46	0.00	0.27	0.43	1.00	1.00	0.62	0.00	0.00	0.00
Sample 5	0.53	0.73	0.62	0.45	0.82	0.86	0.00	0.33	0.88	1.00	0.44	0.43
	Y_{13}	Y_{14}	Y_{15}	Y_{16}	Y_{17}	Y_{18}	Y_{19}	Y_{20}	Y_{21}	Y_{22}	Y_{23}	Y_{24}
Sample 1	0.00	0.13	0.50	0.56	1.00	1.00	1.00	1.00	1.00	0.50	0.80	0.67
Sample 2	0.33	0.75	1.00	0.00	0.50	1.00	0.50	0.60	0.33	0.00	0.00	0.33
Sample 3	0.58	1.00	0.88	1.00	1.00	0.50	1.00	0.00	0.67	1.00	1.00	1.00
Sample 4	0.25	0.63	0.63	0.33	0.50	0.00	0.00	0.40	0.00	0.25	0.40	0.00
Sample 5	1.00	0.00	0.00	0.56	0.00	0.50	0.50	0.60	0.67	0.75	0.20	1.00

Table 3 sample output data

sample				
1	2	3	4	5
7.38	4.92	9.24	5.13	9.05

Note: these sample output data are acquired with Delphi method

4.2 Network parameter selection

1) Selection of input level node number

The number of input level nodes is also the index number of food logistics system. The evaluation system of this paper consists of 24 indexes.

2) Selection of smooth factors

Different value of smooth factor leads to different error value. In this paper, the values of smooth factors are (0.1:0.1:1); results are tested and compared.

4.3 Sample test and result analysis

The first four samples are selected as training samples. After that, all samples with concentrated samples are trained. This paper applies the generalized regression neural algorithm toolbox of MATLAB R2010a and acquires different network approximation errors with different smooth factors. The approximation values of network training samples and errors of training samples are shown in figure 2.

Figure 2 shows that the smaller the smooth factor is, the better the approximation performance of generalized regression neural network is and the smaller error of training samples is. When smooth factor is 0.1 or 0.2, both approximation performance and test performance meet the requirement of evaluation. Therefore, the value of smooth factor can be [0, 0.2].

Test proves that generalized regression network is applicable in evaluation of food logistics system. It provides food manufactures with a very useful tool in selecting, evaluating and managing food logistics system. Furthermore, programming of generalized regression neural network algorithm is very simple, with a relatively small number of parameters needs to be adjusted. Therefore, generalized regression network is effective in the evaluation of food logistics system and has competitive advantage in systematic evaluation and computation.

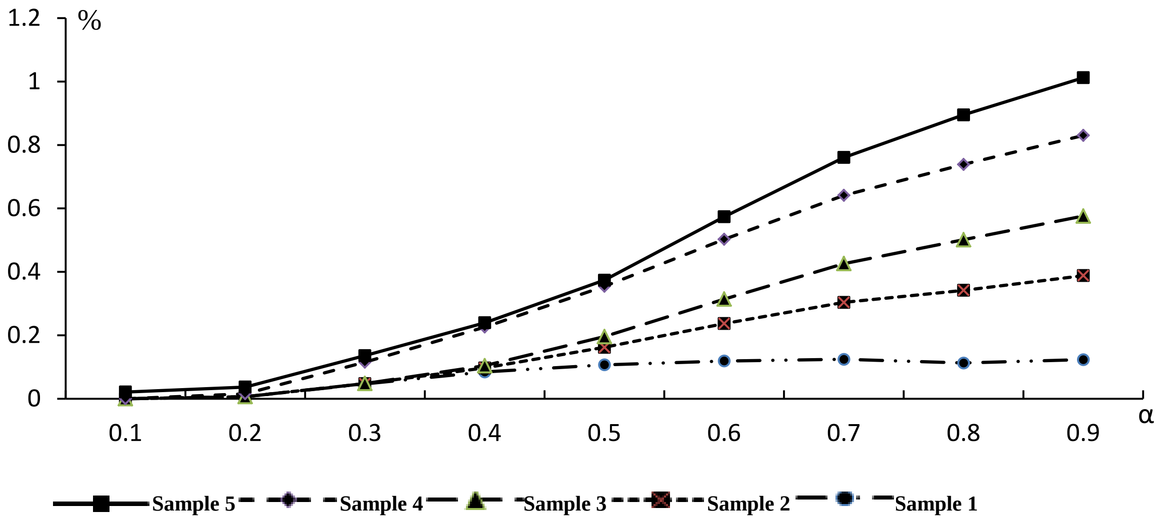

Figure 2Approximation value of generalized neural training samples and errors of training samples

CONCLUSION

In food logistics, logistic environment and operation are two significant factors which can affect food security. This paper applies the method of generalized regression neural network to establish a food logistics system evaluation model. A fairly satisfying result is acquired. This paper provides food producers with an effective tool to select, evaluate and manage food logistics system.

In conclusion, this paper's innovation and research finding are as follows: 1) establishment of an evaluation system for food logistics system based on previous studies; 2) construction of a food logistics system evaluation model with generalized regression neural algorithm. This paper also has some shortcomings and future studies can overcome them from the following perspectives: 1) extent the scale of training samples to make the generalized regression neural network evaluation model more accurate; 2) optimize the study of generalized regression neural network to improve the neural computing speed and accuracy.

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