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Application of Neural Networks Model to Assess Agricultural Products Safety Risks

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Abstract: Presently lack of scientific evaluation method would be an obstacle to development of Chinese agricultural products industry. According to its own characteristics of agricultural products , we selected five first-level indicators such as land uses, land analysis and detection, irrigation water, environmental management and availability of base management system and 17 secondary indicators such as historical security of cultivated fields, suitability of soil structure condition, suitability of microbial content, resources protection and usage of information technology, to establish evaluation index system. In evaluation with artificial neural network, the established BP neural network was trained with data collected from famous food base of China. Simulation shows the maximum error between output of BP network and the assessing score of the experts is merely 0.36% and the result supports the application of back-propagation model to evaluate the Chinese agriculture products safety risks.

Key words: Agricultural products, risks assessment, neural network

INTRODUCTION

Changes in food production and consumer habits, as well as increasing trade liberalization and economic globalization, have made food safety an increasingly important global issue. Producing area is the source of agricultural products quality chain. In order to safeguard agricultural products quality safety, it is essential for the society to control the source of agriculture (Shen, 2011). In China, the consumers' demand of food has been advanced from quantity to quality. However, as far as the truth about China, the food safety incidents happened time after time without the lack of food safety supervision and control. This is largely attributed to merely focus on control over terminals. As is well-known, Overmuch input of chemical fertilizer (nitrogen and phosphorous) and pesticide is the main source of the agriculture non-point pollution. Deteriorating of the rural ecological environment has seriously affected Chinese competitiveness of produce, the sustainable development of agriculture, peasantry's income, the rural stability (Ahumada and Villalobos, 2009).

Risks assessment is the crucial technological basis of food safety management (Wang and Zhang, 2009). Risks assessment of agricultural pruducts quality has made an transition from terminal manament to risks control which is the fundamental crux to food safety, as well as an access to facing agriculture globalization and improvement of agricultural competitiveness. Developed countries have been actively exploring and practising risk management mode based on risks assessment. The European Food Safety Authority (EFSA) has been established to implement risk assessment which is a risks assessment framework drafted by EU in 2002. In the U.S., an interagency risks assessment union was set up in 1997. Japan found food safety commission in 2003 which issues the absolute authority in risks evaluation conclusion at the request of the prime minister and government (Van der Vorst, 2006).

Although research on agricultural products safety has become a hotspot issues in the present academic circles at home and abroad, mojority of study topics focus on the basic theories such as knowledge, cause and management strategy of agricultural products safety rather than systematic research on quantify model.

Lack of scientific evaluation method would be one of obstacle to agricultural products safety management. Back-propagation neural network model is a typical model, suitable for the system under the action of multiple factors.With excellent ability of function approximation; neural networks are widely used to develop the map between be practical and expected data to carry out the evaluation. In the study, a comprehensive assessment index system on agricultural products safety was established and evaluated with artificial neural network and by using MATLAB software, the established BP

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neural network was trained and simulated. Our findings support the application of back-propagation model to evaluate the safety risks.

EVALUATION INDEXES SYSTEM FOR AGRICULTURAL PRODUCTS SAFETY

Framework of index system: This study aims to analyze the agricultural products risks with data from Chinese agri-food base. For the sake of assessment, it is essential for us to establish a framework of index to evaluate. According to its own characteristics of agricultural products quality, we select five first-level indicators such as land uses, land analysis and detection, irrigation water, environmental management, availability of base management system and fourteen secondary indicators to establish evaluation index system as Table 1 shown.

Description of index system: Among index system, the basic indexes include 5 first-order items such as land uses, land analysis and detection, irrigation water, environmental management and availability of base management system, under which have 17 second-order items. To be specific, land uses situation have two dimensions as historical security of cultivated fields and control over latent hazards. The former records the security accident of particular cultivated fields in history and the latter describe the possible future hazards. Land analysis and detection situation can be illustrated not only in such factors as control over residues of pesticides and heavy metals, but also in adequacy of soil nutrient and suitability of soil structure condition. Index of irrigation water is composed of adequacy of water, suitability of water quality and microbial content, as well as pollution control degree of irrigation water. How to maintain a correct understanding on the relation between government leadership and public participation and set up a complete environmental management system is crucial to the society. In the study, we identify the factors to describe the situation of environmental management such as surrounding environment of cultivated fields, ecological environmental protection and resources protection.

Table 1: Evaluation indicators

First-level indicators	Secondary indicators
Land uses	Historical security of cultivated fields (U1)
	Control over latent hazards (U2)
Land analysis and detection	Control over residues of pesticides (U3)
	Control over heavy metals (U4)
	Adequacy of soil nutrient (U5)
	Suitability of soil structure condition (U6)
Irrigation water	Adequacy of water (U7)
	Suitability of water quality (U8)
	Suitability of microbial content (U9)
	Control over pollution of irrigation water (U10)
Environment management	Surrounding environment of cultivated fields (U11)
	Ecological environmental protection (U12)
	Resources protection (U13)
Availability of base management system	Technology management (U14)
	Identification and traceability management (U15)
	Usage of information technology (U16)
	Coordination with government system (U17)

Available management system in food base has significant effect on agricultural products risks which need valid identification and traceability management with the application of new information technology. For example, in the current world, trends like the Internet of Things, big data and real-time data are poised to impact the human experience in many different ways and certainly bring far-reaching influence to the agriculture. Availability of management system also reflects in the ease of linking with government agencies. It is necessary and fundamental for food base to coordinate with authorities in China which is not only beneficial for government agencies to carry out supervision and control but also for those bases to understand the authority policies and master latest information, thus reduce "lemons market" effect to some degree may because of the existence of information asymmetry.

ESTABLISHMENT OF BACK-PROPAGATION MODEL

Model of back-propagation network is a classical artificial neural network model based on multilayer feed forward neural network artificial neural network with the error back propagation learning algorithm. Artificial neural network is a sort of complex network with characters of highly non-linear, self-study, associational memory, dynamic management and tolerance of error, etc. The learning process in BP algorithm is generally divided into two steps of a forward and back propagation. The signal inputs from the input layer, transmitted to the output layer through the hidden units and result in an output signal at output end. If the output expected would not be obtained at output end, it will launch the second step (Balachandran and Radhakrishnan, 2005). The second step is back propagation of error signal. In the process of transmission, network weights and threshold will be adjusted by the error feedback, thus actual output would be closer and closer to the output expected through such an adjustment. Provided the network output realize the error requirement or training action arrives the redesigned times of learning, the learning process would terminate, if not the weights and threshold of back propagation would continue to be adjusted. As is seen, by back-propagation network its learning rule is to use the steepest descent method to continuously adjust the weights and thresholds, so minimize the sum of squared errors of network (Chen *et al*., 2004).

Network layer and neurons number: As any closed interval continuous function can be approached through a BP neural network with a hidden layer, any n-dimensional to m-dimension mapping chaotic system may be finished in a three layer BP neural network (Thomas, 2002). In the study, we choose a three-layer BP neural network which has one hidden layer, According to the foregoing evaluation index system and indicators selected, the input node of BP network model may be confirmed and 17 indicators are taken as the input neuron of the BP model. For calculation, we apply empirical formula as follows:

$$n_i = \sqrt{n + m} + \alpha \tag{1}$$

n_i means hidden layer neuron number, m means output layer neuron number, n means input layer neuron number, α means the constant from 1 to 10. Next, we determine that the node number of hidden layer is eight and neuron number of output layer is one. Here, we use Sigmoid excitation function in which the data range of output status is [-1, +1] and rigidity adjusted by coefficient x with the function format as follows:

$$f(x) = \frac{1}{1 + e^{-x}} \tag{2}$$

Network learning parameter: As any closed interval continuous function can be approached through a BP neural network with a hidden layer, any n-dimensional to m-dimension mapping chaotic system may be finished Since the system to be evaluated is nonlinear,selection of initial value has a great impact on whether learning can reach local minimum, convergence and the length of training time. Every output value of neuron after initial weighting tends to approach zero, thus weight value of each neuron would be adjusted when the change of their Sigmoid function is at maximum. Learning velocity determine the changing volume of weighting value and threshold in every revolving training process. We select changing adaptive learning rate in order to make network training automatically set the learning rate in different stage. Basically, the range of the learning rate is from 0.01 to 0.8.

For the sake of evaluating with BP network, it is initial to collect suitable samples to train.

EVALUATION OF BACK PROPAGATION MODEL

Collection and transaction of training sample data: We took data from famous Chinese agricultural production bases as samples to train. Agricultural production base in China are mainly distributed in the Northeast area, Huanghuai area, Yangtze river basin region, South and Northwest regions.

The land area of Northeast religion is 1.0368 minllion km^2, where there is bulk farm-products supply base with main products of maize, soybeans, rice, sugar, beet, meat and milk and grain production occupied at 17.35% of national total production. The land area of Huanghuai area is 296.9 thousand km^2,where there is bulk farm-products supply base with main products of wheat, maize, cotton, oil, meat and milk and grain production occupied at 20.99% of national total production. The land area of Yangtze river basin region is 1.2638 minllion km^2,where there is bulk farm products supply base with main products of rice,wheat, cotton, oil, meat and aquatic products and grain production occupied at 33.39% of national total production. The land area of South region is 170.5 thousand km^2,where there is supply base of rubber, sugar cane and other tropical cropswith with main products of rice, meat and aquatic product and grain production occupied at 3.28% of national total production. The land area of Northwest region is 2.3367 million km^2,where there is supply base of cotton, sugar and beet melon with main products of rice and beet and grain production occupied at 3.26% of national total production.

Then we invited experts to evaluate the indicators of specific cases. The designed state N = {100-90, 90-80, 80-70, 70-60, 60-0} which status accordingly means {very good, good, ordinary, bad, very bad}, as the Table 2 shows. The comprehensive scores of samples are shown in Table 3 which are determined by the experts according to the designated state, expressed as S. S = {0.5-1.5, 1.5-2.5, 2.5-3.5, 3.5-4.5, 4.5-5.5},which status accordingly means {very good, good, ordinary, bad, very bad}.

We apply soft of MATLAB7.0 to transact these data. In order not to maximize the absolute input of BP network to enter into the error surface zone,it is essential to standardize (normalized) these data to control the input and output data limit in [0, 1]or [-1, 1]. Such standardization (normalized) of vectors can be realized through function of "premnmx" in MATLAB which format is as follows:

Table 2: Index scores of each sample

	Sample							
Index	1	2	3	4	5	6	7	8
U_1	90	90	88	85	90	85	83	93
U_2	85	88	87	84	87	80	89	90
U_3	88	93	89	88	90	79	88	94
U_4	87	94	85	85	93	74	91	90
U_5	86	95	87	82	92	70	90	88
U_6	84	85	89	90	89	78	85	95
U_7	89	89	92	83	90	69	80	91
U_8	86	88	90	91	94	85	85	96
U_9	78	87	90	86	91	78	75	98
U_{10}	88	89	90	88	90	87	78	95
U_{11}	80	93	87	90	90	83	75	92
U_{12}	91	92	86	87	82	78	89	95
U_{13}	83	95	73	85	76	87	90	96
U_{14}	85	93	75	84	82	89	79	94
U_{15}	81	92	78	81	81	89	83	93
U_{16}	89	97	90	88	77	93	73	90
U_{17}	90	95	92	82	73	95	88	92

Table 3: Compresensive score of each sample

	Sample							
Score	1	2	3	4	5	6	7	8
	2.7	1.6	2.9	3.1	1.9	4.2	3.3	1.1

[pn, minp, maxp, qn, minq, maxq] = premnmx(p, q)(3)

[pn, minp, maxp] = premnmx(p) (4)

Here, p means input vector of network; q means target output vector; pn presents quantifiable input vector; minp presents minimization of input vector; maxp is viewed as maximization of input vector; qn is viewed as quantifiable target vector; minq is minimization of target vector; maxq is maximization of target vector. Result of Matlab is shown in Fig. 1.

Establishment of BP model: We took data from famous Chinese agricultural production bases as saWe choose BP neural network as a 17-8-1 three layer network structure which is a network composed of seventeen input layer neuron, eight hidden layer neuron and one output neuron. In the study, we determine delivering function of hidden layer as “tansig”, delivering function of output layer as “purelin”. Considering limitation of sample volume, it is better to choose improved algorithm for training to avoid the disadvantage of traditional algorithm of BP network. So function "traingdm" with the momentum of the gradient descending method is applied as training function. The momentum tends to reduce the network sensitivity of error surface details. In the gradient descending method is applied as training function.

The momentum tends to reduce the network sensitivity of error surface details. In the gradient descending method, the weighting value is corrected along the direction of negative gradient in K time, without consideration of historic experience, namely, previous gradient direction, thus concussion occur during the learning process and convergence become slow. thus the improved algorithm is as follows:

$$w_{ji}(k+1) = w_{ji}(k) + \eta\left[(1-\alpha)D(k) + \alpha D(k-1)\right] \quad (5)$$

where, D(K) means negative gradient in K time, D(k-1) means negative gradient in time of k-1 η means learning rate momentum means $\alpha \epsilon [0,1]$.

When $\alpha = 0$ weighting correction has relationship with current negative gradient; when $\alpha = 1$ weighting correction depend on negative gradient of last cycle. In this method, the momentum as equivalent of damping item reduce the volatility trend during learning process and improve the convergence.

We set the BP neuron network training parameter through function "net.trainParam". Here, two items of BP network will be set, namely the maximum tolerable error(net.trainParam.goal) and maximum learning times (net.trainParam.epochs) and other parameters select default value. We designate the maximum tolerable error as 5000 times and the maximum learning times as 10^{-5}, with the following specific code net.trainParam.epochs = 5000 net.trainParam.goal = 0.00001

Training result and simulation: After calculation through MATLAB, training result of BP neuron network is shown in Fig. 2, in which the demand of target realize precise of 10-5 after experiencing iterative 1910 times. The function of Sim is applied to simulate the network after trained which call format is as follows:

[Y, Pf, Af, E, perf] = sim(net, P, Pi, Ai,) (6)

Here, Y means output of network; Pf means the input delay status in training termination; Af means the layer delay status in training termination ;E means error between output and target vector; perf means network performance; net means simulated network means input of network; Pi means the initial status of input delay;

Ai means the initial status of layer delay; T means target vector. For the sake of application, we select Pf, Af, E, perf, Pi, Ai, T as default value of network and apply function “postmnmx” to release the data standardized (normalized) function "premnmx", with specific call format:

[q1] = postmnmx(q1n, minq, maxq) (7)

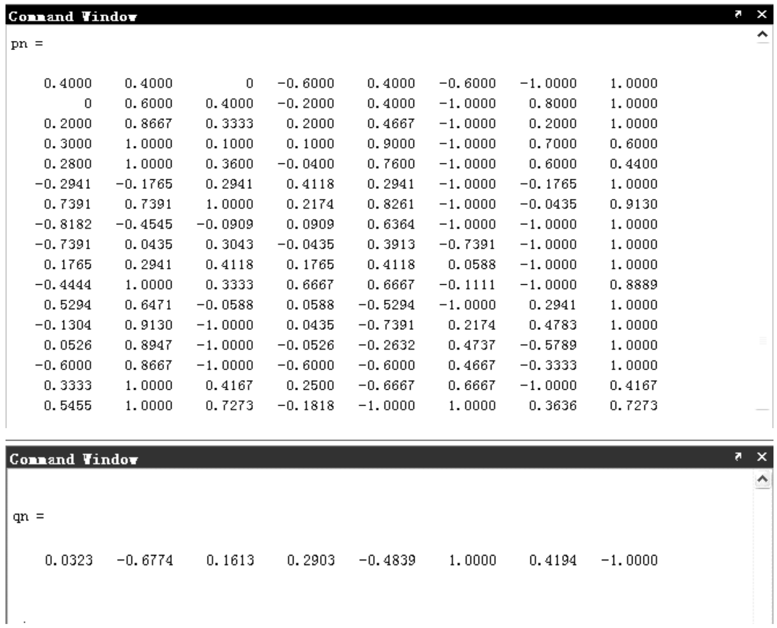

Fig. 1: Example of a figure caption

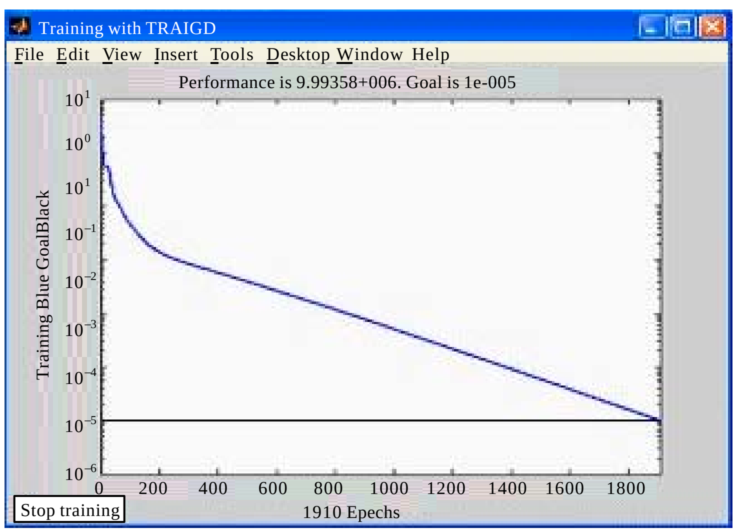

Fig. 2: Error curve of network training

Here, q1 means data after reverse normalized;q1n means output of neuron network; minq means the minimum value of target vector; maxq means the maximum value of target vector.

With above function, the error between output of BP network and the evaluation score of the experts means showed as Table 4.

It can be found that the maximum error between output of BP network and the assessing score of the

Table 4: Error between output of BP network and the assessing score of the experts

Sample	Score of expert	output	Error %
1	2.7	2.697	0.10
2	1.6	1.6013	0.08
3	2.9	2.9046	0.15
4	3.1	3.0889	0.36
5	1.9	1.9043	0.22
6	4.2	4.2032	0.08
7	3.3	2.2326	0.19
8	1.1	1.099	0.09

experts is no more than 0.36%, therefore the training result is satisfactory.

CONCLUSION

By the work of the immanent connection of data known, BP neural network establishes the nonlinear mapping relationship between the input and output, thus carry out forecast and judgment to new input. For the calculating time of BP neural network model, it is not necessary to set up any precise mathematical model, nor any premise and hypothesis and just need direct and simple methods and high modeling accuracy. It can be shown in the simulation results of BP neural network that by application of BP neural network comprehensive evaluation result on agriculture products risks is accordance with expert ratings.

As a result, another kind of train of thought and method can be applied to evaluate the risks of agriculture products with the neural network model based on the collection and assessment of relevant indexes. As for control over Chinese agriculture product risks, there are a series of measures to take up according to China's actual conditions. At the outlet, it is essential to identify and control the latent hazard in food base affecting agriculture produce and applicable alternatives are taken to improve the land condition and control the heavy metal. Moreover, it is fundamental to protect the neighboring eco-environment of the base, especially reinforce the pollution supervision of irrigate water. Last but not least, further improvements are needed in agriculture product identification and traceable system.

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