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Algorithm Research on Risk Evaluation of Pension Insurance Payment Based on Bp Algorithm

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Abstract: Risk evaluation of basic pension insurance payment can ensure stable and healthy development of national economy and has important practical significance in building harmonious society. This study puts forward a new BP neural network algorithm for evaluating risk of basic pension insurance payment. First, a new indicator system for evaluating risk of basic pension insurance payment is established from the perspectives of system operation, system design and environment; Then the study improves BP neural network algorithm through optimizing its learning rate, adopting orthogonalizable design and optimizing the form of training sample to simplify the algorithm structure and improve efficiency; Finally, the established evaluation indicator system and presented BP algorithm are realized by the data from some city to carry out comprehensive risk evaluation of basic pension insurance payment and the experimental results indicate that the model has favorable evaluation results.

Key words:BP neural network algorithm, risk evaluation of basic pension insurance payment, learning rate, orthogonalizable design, evaluation indicator system

INTRODUCTION

In recent years, because the basic endowment insurance fund system design is not perfect, the proportion of payment is unreasonable and the substitution rate is too high and the basic endowment insurance in the world is facing the crisis of insufficient capacity to pay. Coupled with the arrival of an aging population, the basic pension insurance fund payment management is facing various unknown challenges which will threaten the stability of the whole society. Therefore, it is urgent for governments to establish a scientific, reliable management method to carry out early-warning, ensure the safety of fund. So how to realize risk warning for basic pension insurance payment, including establishing a reasonable risk evaluation indicator system and designing risk evaluation method, has become a hotspot for the governments and researchers related.

As for risk evaluation of basic pension insurance payment, much emphasis is laid on the following methods at present. Statistical analysis method, through statistics method, makes statistical analysis on each evaluation indicator of basic pension insurance payment, evaluates the scores of each evaluation indicator, so as to obtain the risk warning level. The evaluation process of the method is easy to understand, also reflects specific evaluation and attitude of basic pension insurance payment. But it is cumbersome in evaluation process and low in evaluation precision , BP neural network evaluation method, although BP neural network has such advantages as self-learning, strong fault tolerance and adaptivity, this algorithm is easy to fall into the defects like local minimum, over-learning and strong operation expertise. Fuzzy comprehensive evaluation has the greatest advantage of favorable performance evaluation effects as to multi-factor and multi-hierarchy complicated problems. But the definition and calculation of membership and membership function of fuzzy evaluation method are too absolute, difficult to reflect the dynamic nature and intermediate transitivity of risk evaluation indicators of basic pension insurance payment (Yang, 2011, 2012).

The study improves BP neural network algorithm through optimizing its learning rate, adopting orthogonalizable design and optimizing the form of training sample to overcome the question of slow convergence of original BP model. In so doing, a new algorithm for evaluating risk of basic pension insurance payment is presented.

ESTABLISHMENT OF EVALUATION INDICATOR SYSTEM

Evaluation indicators and is the main contents for the establishment of Evaluation indicator system. The set of indicator system shall be able to measure and evaluate the

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Table 1: Risk evaluation indicator system of basic pension insurance payment

Target hierarchy	First-grade indicator	Second-grade indicator	Calculation or describing method
Risk Evaluation of basic pension insurance payments	System operation	Support rate	Number of employees getting pension/Number of in-service employees
		Increasing rate of retirees	(Increase of Retirees Number in this year)/Number of retirees in last year
		Substitution rate of pension insurance fund	Pension received by retirees in the corresponding period/Average wage of in-service employees
	System design	Individual payment rate	Payment rate as stipulated by laws and regulations related to pension insurance
		Unit payment rate	Payment rate as stipulated by laws and regulations related to pension insurance
		Interest rate	Deposit interest rate of financial institutions as stipulated by national relevant departments
	Environment	GDP growth rate	(Actual GDP growth in this year)/Actual GDP in last year
		Growth rate of average wage of employees	(Increment of Wage of in-service employees in this year)/ Average wage in last year
		Average life expectancy of retirees	Data of Bureau of Statistics
		Death rate	Data of Bureau of Statistics

payment capacity of pension insurance fund. While designing the indicator system of risk evaluation of basic pension insurance payment, Therefore, this stuyd first refers to literatures of the fields and experts' opinions, according to relevant principles of risk evaluation of basic pension insurance payment, deciding the scope of influence of research objects by combining area method with goal method and designing evaluation indicator system with such three perspectives of system operation, system design and environment. The system includes 3 first-grade indicators, 10 sec-grade indicators, Table 1 with more details (Yang, 2011, 2012).

EVALUATION ALGORITHM DESIGN

Working principles and steps of BP neural network algorithm: The working steps of BP neural network are as follows: (1) Initialization. Including initialize weight value matrix U andW, set learning rate η and error accuracy ϵ or maximum training times with random numbers, (2) Successively input Q pairs of learning samples, (3) As for current input sample Q, calculate the output u^q_j and y^q_k of each neuron layer by layer, in which $j = 1,2,\ldots,m$, $k = 1,2,\ldots l$, (4) Calculate error signal of each layer δ_{jk} and δ_{ij}; calculate δ^q_{jk} and δ^q_{ij} according to Eq. 1 and 2, (5) Make a judgment on whether the input of training samples comes to an end. If q<Q, turn to Step (2) to continue the calculation; if q = Q, turn to Step (6), (6) Adjust the weight values of each layer. Amend Eq. 3 and 4 according to weight values, adjusting the weight values of each layer, (7) Make a judgment on whether the learning comes to an end according to error accuracy or maximum training times (Zhang *et al.*, 2012):

$$\delta_{jk} = (d_k - y_k)y_k(1-y_k) \tag{1}$$

$$\delta_{jk} = \sum_{k=1}^{l} \delta_{jk} w_{jk} v_j (1-v_j) \tag{2}$$

$$w_{jk}(t+1) = w_{jk}(t) + \eta \sum_{q=1}^{Q} \delta_{jk} v_j \tag{3}$$

$$u_{ij}(t+1) = u_{ij}(t) + \eta \sum_{q=1}^{Q} \delta_{jk} v_j \tag{4}$$

Optimizing learning rate of BP algorithm: Generally, when neural network model enters later phase of training, the link weight values among neurons become more stable; at this time, the learning rate shall be smaller, as larger learning rate is easy to make the modification process of weight value W oscillate. While at the beginning of training, in order to accelerate the rate of convergence of network, the learning rate is often adjusted to a large value, which makes it necessary to dynamically change learning rate in learning process. The criterion for changing learning rate is to check whether the modification value of weight value actually reduces the error function. If yes, it means that the adopted learning rate is too small and another increment can be added; if no, the value of learning rate shall be reduced. Optimization adjustment formula for changing learning rate method sees Formula 5, in which η is learning rate, l is training times, E is error function, α, β and k are rate factors, the values of which in this thesis are $\alpha = 1.02$, $\beta = 0.8$, $k = 1.04$ (Scott, 2010):

$$\eta_{l+1} = \begin{cases} \alpha\eta_l, \alpha \geq 1, E_{l+1} \prec E_l \\ \beta\eta_l, \beta \leq 1, E_{l+1} \succ E_l \\ \eta_l, \quad \text{other} \end{cases} \tag{5}$$

where, in order to avoid that model training falls into slight local minimum point, momentum can be considered to be introduced; weighting adjustment formula with momentum is Eq. 6:

$$E = \frac{1}{2}\sum_{q=1}^{Q} E_q = \frac{1}{2}\sum_{q=1}^{Q}\sum_{k=1}^{1}(d_{q,k} - v_{q,k})^2 \qquad (6)$$

where, and start the back propagation of error after finishing the learning of all the training samples, i.e., updating link weight values of each layer. When BP neural network algorithm is applied in batch adoption, its quantity of samples shall be more than 100.

Orthogonalizable design to optimize BP algorithm: In order to further optimize BP neural network algorithm, this thesis adopts orthogonalizable design method to optimize relevant parameters of BP neural network. Variables intended to be chosen are nodes of hidden layers, accuracy requirements and transfer function. Each variable can choose two levels. Training function adopts gradient descent and LM method; the number of neurons of hidden layers can also be chosen between two levels, less than 7 or more than 7; required by training can be high accuracy or low accuracy (Wang and Tan, 2013).

This study, making orthogonalizable design to optimize H, adopts 7 nodes, algorithm accuracy as $\epsilon<0.001$, transfer function as traingdx function. First, BP neural network learning input adopts n evaluation indicators, thus preliminarily determining n indicators used for establishing system model. Also adopt m in effective sample M as training samples (M>m), M-m as test sample. The algorithm process is designed as below: (1) Randomly divide sample data into two groups, (2) Respectively establish two groups of Matlab analysis programs, (3) Carry out simulation with original data, (4) Carry out simulation with original data, (5) Analyze simulated results, (6) Compare simulated results of the test with actual results, make a judgment on whether needs to rebuild model; if yes, turn to the 3rd step, if no, the simulation process finishes (Liu, 2013).

Optimizing training samples: Optimize training samples is also put forward in this study: (1) First carry out factor analysis on original data sample, synthesizing the several indicators of sample into a few factors and obtaining factor score, (2) Calculate Euclidean distance between samples with factor score to carry out clustering analysis, dividing samples into several subclasses, (3) Scientifically choose samples in appropriate amount according to certain proportion from each subclass. Through the above analysis and processing, we can obtain optimized training sample set (Yueh, 2010).

EXPERIMENT CONFIRMATION

Data collection and pretreatment: As Shanghai is the first Chinese city entering aging of population with the phenomenon of inability to make the income meet the expenditure as for basic pension insurance fund, it is equipped with strong representativeness; also in consideration of the availability of data, this study adopts basic pension insurance fund in Shanghai as statistical object. This study chooses relevant indicators data in "China Labor and Social Security Yearbook" and "Shanghai Statistical Yearbook "from 2000 to 2012, totaling 13 groups, in which 12 groups of data are used for learning process of BP neural network model and the left 1 group of data are used for testing the accuracy of network model after training.

After collecting data, in consideration of the range of input value of neural network, pre-processing is carried out according to Eq. 7. In Eq. 7, X' means the results after data standardization, max (X_i) means the maximum value, min (X_i) means the minimum value:

$$X' = [2*(\max(X_i) - X_i)/\max(X_i) - \min(X_i)] - 1 \qquad (7)$$

Network structure configuration: Adopt the following parameters in model operation: learning rate being 0.01, system error being 0.001, running times being 18000; adopt Sigmoid function, i.e:

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

where, as activation function; number of nodes in input layer being 10, that in output layer being 1; "Error and Trial" method is adopted for the determination of number of nodes in hidden layer, first determining the number of nodes in hidden layer with less quantity to carry out the training; if no convergence occurs within the stipulated training times, stop the training and gradually increase the number of nodes in hidden layer, continue to re-train; this study selects four situations, respectively 8, 12, 14, 16. Through several times of repeated training, finally determine the number of nodes in hidden layer as 14. Therefore, BP network model structure in this study is 10X14X1. Initial values of weight matrix are the random matrix of 10X14 order and 14X1 order, respectively.

Experimental results and analysis: The study realizes the presented BP algorithm, the ordinary BP algorithm (Yueh, Y., 2010)and ordinary fuzzy evaluation method(Yang, Z.A., 2011) with C language. In setting warning grades, this study adopts traditional method, i.e. evaluation result lower than 0.5 is safe; value of evaluation result lying in (0.5, 0.65) is slight warning; value of evaluation result lying in (0.65, 0.8) is medium warning; value of evaluation result lying in (0.8, 1) is severe warning.

Table 2: Final evaluation results of different years

	2001	2003	2005	2007	2009	2011
Final Evaluation	0.323	0.681	0.775	0.910	0.298	0.261
Warning Level	Safe	Slight warning	medium warning	severe warning	Safe	Safe
Warning signal	Green	Blue	Orange	Red	Green	Green

Table 3: Evaluation performance comparison of different algorithms

	Algorithm in the study	Ordinary fuzzy model	Ordinary BP Algorithm
Evaluation Accuracy	4.172	4.113	4.099
Time Consuming (S)	4.641	3.992	4.602

As for the performance of the presented algorithm, this study also realizes the application of the ordinary BP neural network and ordinary fuzzy algorithm, evaluation performance of different algorithms is shown in Table 3. In Table 3 evaluation results of training effects of risk warning are selected and compared with artificial evaluation to calculate the evaluation accuracy. And the calculation platform as follows: hardware is Dell Poweredge R710, in which processor is E5506, memory 2G, hard disk 160G; software platform is Windows XP operating system, C programming language environment.

CONCLUSION

Based on the specific features of risk evaluation of basic pension insurance payment, the study designs a new evaluation indicator system. And based on the analysis the advantages and disadvantages of, the study uses the powerful nonlinear processing ability of BP neural network algorithm and takes corresponding measures to simplify the algorithm structure and improve evaluation accuracy and speed up calculation speed. The experimental results show that the algorithm presented in the study can realize above purposes when used to evaluate basic pension insurance payment risk.

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