Teaching Quality Evaluation Method Based on Multilayer Feedforward Neural Network

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Abstract. In order to promote the development of education, multi-layer feedforward neural network is applied to the teaching quality evaluation process, and a new evaluation method is proposed. The evaluation model based on multilayer feedforward neural network is established. The experiment data is used to compare the results of the experimental group and the control group. The results show that the application of multilayer feedforward neural network to the evaluation of teaching quality can reduce the error between the target output and the actual output, and make the quality evaluation result more in line with the actual situation.

Keywords: Multilayer feedforward neural network · Teaching quality · Evaluation method

1 Introduction

Since 1999, the scale of enrollment in colleges and universities has been enlarged, which is unprecedented in the history of China's higher education, and unprecedented in the history of the world's higher education. On the one hand, the enrollment expansion of higher education has promoted the adjustment of our country's economic structure and played an active role in realizing the sustainable development of our country's economy; on the other hand, the school-running ability and educational quality of institutions of higher learning have undergone tremendous tests under such extraordinary expansion. The quality of running colleges and universities will directly affect the development of higher education in our country. The quality of teaching in institutions of higher learning is reflected by the quality of teaching in various specialties or departments, and the quality of teaching in institutions of higher learning is reflected by the quality of courses, and the quality of courses is reflected by the quality of teaching of teachers undertaking the courses [1].

Feedforward neural network is the simplest kind of neural network in which the neurons are arranged hierarchically. Each neuron is connected only to a previous layer of neurons. Receives output from the previous layer and outputs it to the next layer. There is no feedback between layers. It is one of the most widely used and rapidly developing artificial neural networks. Since the 1960s, the theoretical research and practical

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application have reached a very high level [2]. The feedforward neural network adopts a unidirectional multilayer structure. Each layer contains a number of neurons. In this kind of neural network, each neuron can receive the signal of the first neuron and produce output to the next layer. Layer 0 is called the input layer, the last layer is called the output layer, and other intermediate layers are called hidden layers (or hidden layers, hidden layers). The hidden layer can be one layer or multiple layers. Teaching quality evaluation in colleges and universities is a complicated problem. Multi-layer feedforward neural network is used to evaluate teaching quality.

2 Materials and Methods

2.1 Teaching Quality Rating

The evaluation of teaching quality in colleges and universities is a complicated problem. It includes many factors, such as teaching conditions, course difficulty, teachers' teaching and learning effect, which interact with each other.

(1) Research on the subject of teaching quality evaluation: there are many ways or methods to evaluate teaching quality, such as teachers' self-evaluation, peer evaluation, administrative leadership evaluation, expert evaluation and students' evaluation of teachers, etc. Because of the different roles of evaluation subjects, their roles in the evaluation should be different. Each evaluation method and its results are only a part of the evaluation of teaching quality, and cannot be equated with the whole of teaching quality [3]. Because of the large number of college teachers and frequent evaluations, it is not only time-consuming and laborious for leaders and peer experts to adopt the evaluation method of general survey, but also difficult to operate because of the influence of interpersonal relationship and unfamiliarity with the teaching process. Therefore, the method of student-centered evaluation of teachers' teaching quality is widely adopted by most colleges and universities. Since the eighties of last century, colleges and universities in our country have gradually carried out student evaluation of teaching, which has played a certain role in improving the teaching quality. As the direct object of teaching, students have the right and ability to evaluate the teaching of teachers. Because of the diversity of types, complexity of majors and the uneven level of students, the requirements for the evaluation of teachers' teaching quality are also different [4].

(2) Determination of the content of the evaluation of teaching quality: when designing the content of the evaluation system of teaching level, considering that the learning and development are a continuous process and the environment for learning and growth are diverse, it is very difficult to quantify the role of a certain teacher in a certain course or a certain learning stage, and generally, the evaluation content is placed on the teaching process instead of taking the course performance as the main indicator or teaching effect as the main indicator. From the point of view of process management, the teaching process of school is a combination of many factors and links. It is difficult to compare the teaching of different subjects, different courses, different teaching links and different teaching objects. Therefore, the system of teaching quality evaluation is designed mainly from the aspects of the most basic

factors which can directly reflect the teaching level and have common characteristics [5]. According to the present evaluation system of teaching level, the design of the index is mainly embodied in the following aspects: ① Teaching attitude: whether the teaching is serious and responsible, whether the spirit of class is full, whether the preparation of lessons is sufficient, whether the tutoring, answering questions and correcting homework are serious. ② Teaching content: whether the selection and handling of content are appropriate, whether the concept is accurate and clear, whether the focus is prominent, whether the difficulty and depth are appropriate, whether the theory is closely connected with the practice, and whether the content is rich. ③ Teaching ability: whether the organization is clear, the language is vivid and concise, attractive, focus, difficult to elaborate accurately, whether the writing is neat. ④ Teaching methods: whether to teach students in accordance with their aptitude, whether the method is flexible, whether to focus on inspiring students to cultivate innovative awareness and ability, whether to focus on exchanges with students, interaction [6]. ⑤ Teaching: whether rigorous scholarship, exemplary, strict and fair requirements for students. ⑥ Teaching effect: Whether can promote the student to think positively, whether student's result promotion, whether the student grasps comprehensively to the knowledge spot. Because different schools have different understandings and emphases on teaching quality, there are some differences in the content of evaluation.

(3) The current teaching quality evaluation methods: after the establishment of each index system in the teaching quality evaluation system, it is necessary to process these data with certain methods so as to obtain the final teaching quality grade. This paper summarizes the research on this aspect. ① Traditional teaching quality evaluation methods: the results of traditional teaching quality evaluation depend on: first, the scoring of evaluation indicators; second, the formulation of grading criteria. The evaluation results of each index of the evaluation object are expressed by A, B, C, D , and the proportion of evaluation contents in the evaluation system is determined, 10% for teaching and education; 20% for professional level; 35% for classroom teaching; 20% for organized teaching; and 15% for students' learning quality. Then determine the importance coefficient (proportion) of each content sub-index. When the evaluation subject makes A, B, C, D for each content's sub index, according to the reasonable procedure and scoring method, the quality grade coefficient Xa, Xb, Xc, Xd of each content is obtained, and then according to the proportion of the evaluation content, the grading standard coefficient Ka, Kb, Kc, Kd of the total index is synthesized, and a grading plan is drawn up, For example, excellent is $\mathrm{Ka} \geq 70$, $\mathrm{Kd} = 0$, good is $\mathrm{Ka} + \mathrm{Kb} \geq 70$, $\mathrm{Kd} = 0$, etc.

Fuzzy comprehensive evaluation method: This method uses the theory and method of fuzzy mathematics to deal with each index grade given by the evaluation subject, so as to get the comprehensive evaluation of teaching quality. The specific steps are as follows:

Step 1: Establish factor set U. Take the evaluation content in the evaluation system as factor set $\mathrm{U} = \{U_1, U_2, \ldots U_n\}$, and the sub indexes of each evaluation content constitute set $\mathrm{U_i} = \{U_{\mathrm{i}1}, U_{\mathrm{i}2}, \ldots U_{\mathrm{i}s}\}$, $i = 1, 2, \ldots n$. Determine the weight distribution

$a_i = (a_{i1}, a_{i2}, \ldots a_{is})$ and $\sum_{j=1}^{s} a_{ij} = 1, a_{ij} \geq 0$ according to the function of each sub index, and give the weight of U_i as $A = (A_1, U_2, \ldots A_s)$ and $\sum_{i=1}^{n} A_i = 1, A_i \geq 0$.

Step 2: Set up evaluation set V. In fact, V is to determine the grade of teachers' teaching quality. $V = \{v_1, \ldots, v_m\}$, element $v_j (j = 1, 2, \ldots m)$ are all possible total evaluation results, which can be either numerical value or qualitative description, which can be fuzzy or non fuzzy. For example, in the evaluation level of ten system, $V = \{v_1, v_2, \ldots, v_m\} = \{10, 9, 8, 7, 6, 5, 4, 3, 2, 1\}$.

Step 3: Carry out fuzzy evaluation. A single factor evaluation matrix R is established to evaluate each indicator u_{ij} in U_i, so as to determine its membership degree $r_{ij} (j = 1, 2, \ldots m)$ to evaluation set element $v_j (j = 1, 2, \ldots m)$, From this, a single index evaluation matrix R_i can be formed, so that the comprehensive evaluation $B_i = a_i * R_i$, of U_i can be normalized for each B_i, and the matrix $B = (B_1, B_2, \ldots B_n)^T$ can be obtained, then the comprehensive evaluation of U can be obtained: $B = AR = A(B_1, B_2, \ldots B_n)^T = (A_1, A_2, \ldots A_n)(B_1, B_2, \ldots B_n)^T$, then it can be normalized to B, and the score grade of the teacher is $M = BVT$.

③ Markov chain evaluation method: Markov chain is one of the important processes in probability theory. When evaluating the teaching effect of different teachers, the differences in the students' original knowledge base and other aspects may be eliminated, and the grades of the students in a class (or grade) in a certain examination may be assessed as follows:

Excellent (more than 90 points), good (80–89 points), medium (70–79 points), passing (60–69 points) and failing (less than 60 points), and then, taking this result as the initial state, examine the changes of the second examination results (for multiple examinations, the method is the same) to explain the teaching effect of the teachers during this period, so as to compare the teaching quality of different teachers.

At the beginning of the term, the number of N students in the class with excellent, good, medium, pass and fail in the examination is n_i, respectively, and the state vector at the beginning of the term is $i = 1, 2, 3, 4, 5$:

$$R(1) = \left(\frac{n_1}{N}, \frac{n_2}{N}, \frac{n_3}{N}, \frac{n_4}{N}, \frac{n_5}{N},\right) \tag{1}$$

After the final examination, among the original n_1 students with excellent scores, n_{11} students are still excellent, and n_{12}, n_{13}, n_{14}, n_{15} students are reduced to good, medium, pass and fail, respectively. Therefore, the transfer of students with excellent scores at the beginning of the semester is as follows:

$$\left(\frac{n_{11}}{n_1}, \frac{n_{12}}{n_1}, \frac{n_{13}}{n_1}, \frac{n_{14}}{n_1}, \frac{n_{15}}{n_1}\right) \tag{2}$$

Similarly, the transfer of scores of students who have obtained good grades, medium grades, passed grades and failed grades is:

$$\left(\frac{n_{i1}}{n_i}, \frac{n_{i2}}{n_i}, \frac{n_{i3}}{n_i}, \frac{n_{i4}}{n_i}, \frac{n_{i5}}{n_i}\right)(i = 2, 3, 4, 5) \tag{3}$$

This gives the transition probability matrix:

$$p = (p_{ij}) = \left(\frac{n_{ij}}{n_i}\right)(i,\ j = 1, 2, 3, 4, 5) \tag{4}$$

The transition probability matrix P is the transition change on the original basis, independent of the original basis. According to the properties of Markov chain, the stable distribution $(x_1, x_2, x_3, x_4, x_5)$ can be obtained. If the agreed scores of excellent, good, medium, pass and fail are 90, 80, 70, 60 and 50 respectively, the teaching effect will be quantified as follows:

$$s = 90x_1 + 80x_2 + 70x_3 + 60x_4 + 50x_5 \tag{5}$$

The above teaching quality evaluation methods play a positive role in improving teaching quality and promoting teachers' teaching level. Based on this, a multi-layer feedforward neural network is established.

2.2 Establishment of Evaluation Model Based on Multilayer Feedforward Neural Network

Multilayer feedforward neural networks depend on initial weights and thresholds, which are given randomly. Genetic algorithm searches for the optimal solution in the whole space, which can improve the shortcomings of neural networks based on gradient descent method, such as falling into local minimum and slow convergence. The flow chart is shown in Fig. 1:

A biased network can approximate any rational number if it contains an S-shaped implicit layer and a linear output layer. Among them, the more layers, the more accurate the results obtained, but the increase in the number of layers, the calculation will increase, therefore, the training cycle will increase. The feedforward neural network with single hidden layer can map all continuous functions, and only need two hidden layers when learning discontinuous functions, so the multilayer feedforward neural network only needs two hidden layers at most [7]. When designing a multilayer feedforward neural network, generally speaking, a hidden layer should be considered first. If the number of nodes in the hidden layer is large enough and the network performance is not improved, the training cost will increase with the increase of the number of hidden layers. The input layer receives data from external inputs, so the number of nodes depends on the dimensions of the input vector for the specific problem. The transfer function used in the input layer is generally linear, that is $f(x) = x$. The trial and error method is one of the methods to determine the number of hidden layer nodes. After the initial value is determined, the optimal number can be analyzed by experiment. The initial value of the trial and error method shall be determined in three forms, as shown in formula (6) to formula (8), and the number of nodes of the initial hidden layer shall be determined using empirical formula (6).

$$m = \sqrt{n+1} + a \tag{6}$$

$$m = \log 2^n \tag{7}$$

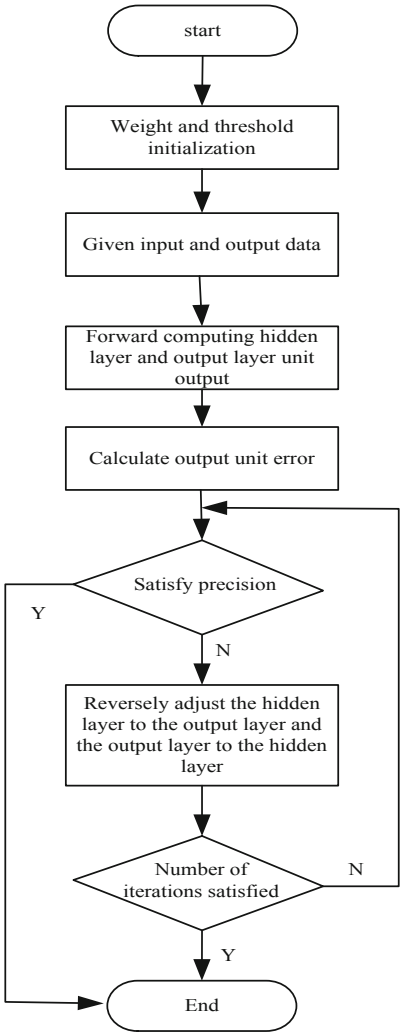


Fig. 1. Flow chart of multilayer feedforward neural network

$$m = \sqrt{nl} \tag{8}$$

Where m is the number of hidden layer nodes, n is the number of input layer nodes, l is the number of output layer nodes, and a is a constant between 1–10.

The number of nodes in the output layer depends on the dimension of the objective variable in the actual problem. The nonlinear transfer function is used. The more commonly used nonlinear transfer function is hyperbolic function formula:

$$f(x) = \frac{1}{1 + e^{x}} \tag{9}$$

Obtain data samples and preprocess the data. In general, the more experimental samples, the more accurate the results of the reaction, but when its number reaches a certain amount, the accuracy is fixed in a range, there will be no change. The larger the size of the network, the more complex the mapping relationship. Generally speaking, the number of training samples is 5–10 times the total network connection weights. Generally, there are two ways to select the initial weights of a network: the first way is to select a small enough initial weights, and the second way is to make the weights of 1 and −1 equal. Learning rate is an important factor affecting the variation of weights in cyclic training. If the value is large, the system will be unstable; if the value is small, the training time will be increased, but the error range can be guaranteed. There are two ways to stop training, one is through error range control, the other is to achieve the maximum number of iterations, two conditions as long as there is one can stop training [8–10]. It is usually possible to train multiple networks and ultimately select the appropriate network based on the analysis results.

3 Results

In order to verify the effectiveness of the above teaching quality evaluation methods, a control experiment is proposed and the test results are obtained.

3.1 Preparatory Process

Setting up the index of students' evaluation of teaching, the students of the college evaluate the practical teaching of teachers, and get the neural network learning and forecasting dataset. After the sample data is screened and processed preliminarily, it is normalized. According to the evaluation index, the number of neurons in input layer and hidden layer and the output layer are determined, and the action function, learning function and performance function are determined. The number of learning iteration, learning rate and error precision are determined, and the sub-neural network is studied by using the training sample data set. Using the corresponding sub-neural network system generated after learning, the prediction data are simulated and calculated by using the prediction sample data set. According to the result of network operation, the effect and feasibility of evaluation are evaluated. In view of the classroom evaluation result of each student in the hospital is only one, the number of output neurons of the neural network subsystem is set at 1. According to the formula for determining the number of neurons in the hidden layer:

$$n = \sqrt{n_i + n_0} + a, 0 \leq a \leq 10 \tag{10}$$

Where, n_i represents the number of neurons in the input layer, n_0 represents the number of neurons in the output layer, a represents the constant, and the value range is $0 \leq a \leq 10$. In the experiment, the number of neurons in the input layer is 10, and the number of neurons in the output layer is 1. According to the formula (10), $n = 4 - 14$ is obtained. According to the experimental results, the optimal number of neurons in the hidden layer is 7.

3.2 Experimental Sample

Training sample data set is a necessary and sufficient condition for network simulation, and the quality of training sample data set directly affects the simulation effect of multi-layer feedforward neural network. Therefore, the selection of training samples needs to grasp the size and quality of the sample data on the basis of analysis and summary. Based on the statistical analysis of the students' teaching evaluation index system, a checklist of practical teaching evaluation is drawn up, and students are organized to evaluate and grade 6 secondary indexes of teaching teachers in an orderly manner. At the end of the assessment process, the student's classroom teaching assessment form will be retrieved.

3.3 Analysis of Results

The evaluation data of the reclaimed classroom teaching evaluation form shall be treated as follows: (1) Since each classroom teaching evaluation requires students to score separately, that is, it is equivalent to having multiple judges. Therefore, this subject adopts the average value of student evaluation after removing the five most scores and five least scores, that is, the data of input neuron indicators of practical teaching evaluation of instructors, so as to exclude the adverse effects of individual subjectivity and other factors. (2) After selecting the suitable sample data, according to the proposed method of multi-layer feedforward neural network evaluation data preprocessing, the sample data is normalized, that is, the student's evaluation data [0, 100] is normalized to the data within the range of [0, 1], so as to reduce the differences between different evaluation data as much as possible, which is convenient for multi-layer feedforward neural network processing. Take the evaluation data of a course teaching student of the college as an example, the processed sample data is shown in Table 1.

Table 1. Student evaluation data

Sample serial number	Secondary evaluation index				Evaluation target		
	X1	X2	X3	X4	X5	X6	
1	0.55	0.61	0.73	0.58	0.76	0.58	0.630
2	0.61	0.60	0.65	0.62	0.71	0.82	0.608
3	0.83	0.88	0.84	0.68	0.61	0.77	0.814
4	0.79	0.60	0.74	0.85	0.61	0.81	0.653
5	0.85	0.87	0.91	0.77	0.8	0.78	0.895
6	0.73	0.72	0.68	0.81	0.66	0.78	0.692
7	0.61	0.63	0.67	0.78	0.83	0.55	0.646
8	0.87	0.92	0.84	0.51	0.62	0.77	0.872

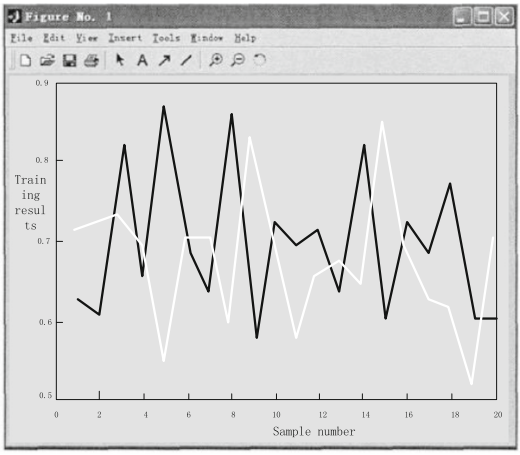
(*continued*)

Table 1. (*continued*)

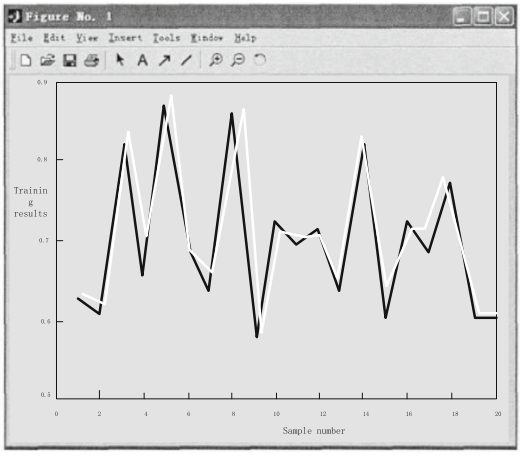
Sample serial number	Secondary evaluation index				Evaluation target		
	X1	X2	X3	X4	X5	X6	
9	0.51	0.62	0.67	0.69	0.72	0.87	0.571
10	0.65	0.61	0.54	0.67	0.81	0.83	0.720
11	0.73	0.71	0.45	0.52	0.76	0.5	0.699
12	0.78	0.66	0.64	0.87	0.81	0.65	0.714
13	0.58	0.60	0.67	0.49	0.7	0.5	0.639
14	0.84	0.78	0.65	0.82	0.87	0.56	0.714
15	0.69	0.54	0.49	0.52	0.85	0.79	0.639
16	0.65	0.61	0.94	0.91	0.85	0.87	0.830
17	0.57	0.45	0.54	0.88	0.75	0.57	0.602
18	0.84	0.90	0.64	0.61	0.87	0.68	0.726
19	0.42	0.75	0.94	0.58	0.78	0.56	0.686
20	0.61	0.60	0.35	0.85	0.57	0.84	0.780
21	0.82	0.63	0.15	0.72	0.81	0.85	0.601
22	0.74	0.78	0.46	0.59	0.78	0.74	0.602
23	0.56	0.64	0.46	0.92	0.81	0.87	0.690
24	0.78	0.82	0.15	0.54	0.79	0.86	0.821
25	0.80	0.88	0.64	0.85	0.53	0.55	0.859

The first 20 groups of data in the table are regarded as the training sample data set, and the last 5 groups of data are regarded as the prediction sample data set. The simulation results of the neural network subsystem model formed after the learning process are verified (Fig. 2).

Compared with the results of the control group, the convergence speed of the multi-layer neural network subsystem used in the teaching quality evaluation is faster. After several iterations, the system error has reached 0. 000273773, and the error between the target output of the training sample data set and the actual output is consistent with the set value ($\leq$0.001). The output value of the system is close to the actual teaching evaluation data, which shows that the neural network subsystem can approach the teaching quality evaluation rules of the training sample data.



(a) Control group



(b) Experimental group

Fig. 2. Experimental control results.

4 Conclusions

Teaching evaluation of college teachers is of great significance to improve teaching quality, teachers' quality and students' learning effect. The evaluation system of college teachers' teaching quality is a kind of high dimension nonlinear relation. After studying some methods of teachers' teaching evaluation and analyzing their advantages and disadvantages, a new method of teachers' teaching evaluation based on multi-layer feedforward neural network is proposed. Different evaluation systems are adopted for

different subjects and different specialties, which makes the evaluation more reasonable, scientific and objective.

References

1. Ma, W., Li, W., Zhao, Y., et al.: Prediction of hot rolling capacity based on deep learning. J. Iron Steel Res. **31**(09), 805–815 (2019)
2. Li, Y., Xie, G., Guan, J.: Research of asynchronous imitating-reading BCI based on extreme learning machine. Comput. Digit. Eng. **46**(03), 479–484 (2018)
3. Xu, L., Lin, H., Qi, R., et al.: Sentiment lexicon embedding based on radical and phoneme. J. Chin. Inf. Process. **32**(06), 124–131 (2018)
4. Fang, R., Shi, Y., Jiang, T., et al.: A study on the activated carbon intelligent dosing system for urban sewage treatment plants based on BP neural network. J. Zhejiang Univ. (Sci. Ed.) **45**(04), 468–475 (2018)
5. Li, W., Chen, B., Li, J., et al.: Surface scratch recognition method based on deep neural network. J. Comput. Appl. **39**(07), 2103–2108 (2019)
6. Wang, Z., Zhang, H.: A fast image retrieval method based on multi-layer CNN features. J. Comput. Aided Des. Comput. Graph. **31**(08), 1410–1416 (2019)
7. Liu, W., Xie, H.: Generation of intelligent fitting pattern based on BP neural network. J. Text. Res. **39**(07), 116–121 (2018)
8. Yu, C.: A cross-domain text sentiment analysis based on deep recurrent neural network. Libr. Inf. Serv. **62**(11), 23–34 (2018)
9. Cao, J., Gong, J., Zhang, P.: Research on neural network model of data-to-text generation. Comput. Technol. Dev. **29**(09), 7–12+23 (2019)
10. Meng, Y., Huang, L., Guo, S.: Global existence and stability of periodic solutions of BAM neural networks with distributed delays. Acta Math. Appl. Sin. **41**(03), 369–387 (2018)