Evaluation Method of Teachers' Teaching Ability Based on BP Neural Network

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Abstract. The evaluation of teachers' teaching ability is an important part of educational activities, and a reasonable evaluation method plays an important role in improving teachers' ability. At present, most of the evaluation methods used by schools and educational institutions are manually formulated some evaluation indicators. These methods are usually influenced by the personal preferences and the implementation is time-consuming. According to these problems, this paper proposes a method to evaluate teachers' teaching ability based on BP neural network. Through constructing the templates, we extract teachers' information and establish the knowledge base. Then a BP neural network is used to teaching ability evaluation. Finally, the experimental results prove the proposed method is effective.

Keywords: Evaluation method · Teachers' teaching ability · Information extraction · BP neural network

1 Introduction

Teachers' teaching ability refers to the individual psychological characteristics which are necessary for teachers to complete teaching activities smoothly and directly affect the efficiency and effectiveness of teaching activities [1, 2]. Teachers' teaching ability directly affects the quality of teaching and its development [3, 4]. Most of the current teaching ability evaluation methods use peer evaluation, expert evaluation and student evaluation [5].

Evaluation index system is the compass of teachers' teaching practice, teachers will constantly revise their own teaching practice according to the evaluation index. Reasonable methods will stimulate teachers' self-improvement motivation, and unreasonable methods will directly lead to the distortion of teaching ability evaluation [6].

The traditional teaching evaluation method has great shortcomings. First, it is greatly influenced by the students' personal preferences, which can not reflect the teachers' teaching ability truly and objectively. Secondly, this kind of evaluation is time-consuming, so it becomes a mere formality in the end, and all the teachers get similar scores, which can not reflect the actual teaching ability of teachers very well [7].

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In the information age, new evaluation methods are needed to make the evaluation process more natural and the results more authentic [8].

This paper introduces a teaching ability evaluation method based on BP neural network. The evaluation method quantifies and classifies the teacher information extracted based on template, to realize the evaluation of teachers' teaching ability.

2 Related Works

Teachers and students are the two major elements of the teaching system. In the past, people only considered students as an element and evaluate the learning effect of students, but ignored teachers as an element. In recent years, educational scholars began to realize that they should consider teachers as an element too. They put forward requirements for teachers' teaching ability, and formulated a series of traditional evaluation methods. As time goes by, the shortcomings of these methods have become more and more obvious, the function of this method has also been ineffective. With the development of computer technology, the method of combining computer technology with teachers' ability evaluation begins to appear. The evaluation method of teachers' teaching ability based on BP neural network is the product of the combination of machine learning algorithm and teachers' ability evaluation.

2.1 Evaluation Method of Teachers' Teaching Ability

In recent years, the academic circles began to use quantitative analysis method to evaluate teachers' teaching ability, and made some progress. Jiajia Liu calculated the weight of each index of teaching ability of university teachers by AHP, and put forward some strategies to improve teachers' teaching ability. Zhihua Wu constructed an evaluation index system of teachers' teaching ability by means of single sample T test, cluster analysis and principal component factor analysis [9].

With the development of computer technology, machine learning algorithms such as SVM, Bayes and Decision Tree are widely used in teaching evaluation. SVM is usually used to find the optimal classification plane in nonlinear space, and ultimately divide the sample data into several labels, to achieve the purpose of intelligent classification [10]. This method realizes the evaluation of teachers' ability through classification.

2.2 Information Extraction

The process of information extraction is mainly to find valuable information from a large number of plain texts, which is difficult to process directly and convert into structured data [11]. At present, there are two main types of text information extraction methods: statistical-based information extraction and rule-based information extraction [12, 13]. The basis of statistical-based information extraction is Statistical model. For example, HMM, maximum entropy, etc. The advantage of HMM-based information extraction is that it is supported by statistical theory. The weakness is that a large amount of training data is needed. Maximum entropy was proposed by E.T. Jaynes in the 1950s and applied to natural language processing in the 1990s [14]. The advantage

is that the feature selection is flexible. The weakness is that the convergence speed of the algorithm is slow and the running time is long. In recent years, natural language processing technology has also been applied to information extraction, and natural language semantic construction improves natural language comprehension ability and analytical skills of the machine [15].

Template-based information extraction technology is widely used in information retrieval systems, such as medical, mechanical dynamics, astronomy, news and other professional retrieval. Information extraction technology based on template matching has been studied for a long time at home and abroad, and the famous template matching methods include SemInt, Cupid, LOLITA, ATRANS and so on [16]. Template-based information extraction has the characteristics of simple operation, high extraction accuracy, easy technical implementation and convenient cooperation with other technologies.

3 Framework

The process of model building is mainly divided into three parts: the construction of information knowledge base, construction of BP neural network and teacher evaluation. The process is shown as Fig. 1.

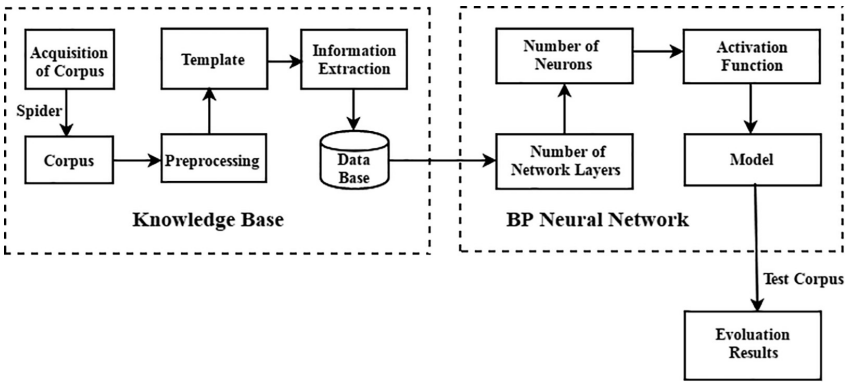

Fig. 1. Framework of model building.

(1) Building a knowledge base. Crawlers are used to crawl the corpus, and ICTCLAS is used for preprocessing. For the information that can not be extracted directly in the process of information extraction, the template is constructed to extract this information. Finally, the extracted information is stored in the database.
(2) Constructing BP neural network. Based on the teacher information stored in knowledge base, the template is constructed. The number of network layers, the number of neurons in each network layer and the activation function are determined according to the template. Finally, a BP neural network model is generated.
(3) Based on the previously constructed model, this paper classifies and evaluates some teachers' corpus.

4 Evaluation Method

4.1 Information Extraction Technology Based on Template

Template-based information extraction technology focuses on the construction of templates. The template construction is determined by the purpose of the information extraction and the structural characteristics of the original text. First, analyze the text characteristics to determine which information need to be obtained. Secondly, through the analysis of the sentence structure of the original text, we have found the characteristics of the required information and whether there is any correlation between all the required information, such as the relationship between sentence structure and part of speech. Finally, the information extraction template is constructed according to the characteristics of the extracted information. A teacher information crawled are shown in Table 1.

Table 1. Teacher information.

Key	Value
Id	1
Name	Lei qi
Image	20111031232035142284453 7_big.jpg
Point	5
Subject	Senior English
Teacher Time	7175
Back Ground	Graduated from Heilongjiang…
Teach Idea	Interest is the best teacher, learning in joy…

When viewing the crawl results, we have found that the teaching time (in hours) is chaotic and irregular, for example 7175 in Table 1. In order to regularize it, the teaching time is discretized, as shown in Table 2.

Table 2. Teaching time discretization.

Serial number	Partition interval
1	time>=0&&time<2142
2	time>=2142&&time<5068
3	time>=5068

The extracted data is stored in the Mysql database. After analyzing the corpus, we have found that the extracted attributes are not perfect for describing the data and cannot be directly used to display the teaching ability of teachers in the knowledge base. The attributes that have been extracted are name, photo, subject, and time of teaching. Because the background part is still in the form of a large text corpus. the background part needs to be further extracted. We will extract three attributes, university, degree and honor, from the background part. We use ICTCLAS as a tool of corpus segmentation and part-of-speech tagging and manual proofreading to ensure accuracy.

The attributes are universities, degrees, and honors that we need to extract in the background corpus. Through the analysis of Back Ground corpus, we have found that the degree attribute has "Bachelor", "Master" and "Doctorate" in the corpus, thus, the keyword matching can be performed. For the university attribute part, after analyzing many background parts, we use the combination of the speech part and named entities to construct a template for information extraction as shown in Table 3.

Table 3. Template of university.

Templates	Example
n+n+n+university	"beijing"/n "aviation"/n "aerospace"/n university
n+n+university	"china"/n "agricultural"/n university
n+university	"shandong"/n university
n+n+college	"beijing"/n "relation"/n college
s+n+university	"northeast"/s "petroleum"/n university
s+university	"southwest"/s university
n+m+n+college	"beijing"/n "second"/m "foreign language"/n college
v+n+college	"Disaster prevention"/v "technology"/n college

The table covers almost all the characteristics of the college name in the corpus. The constructed template is used to match each background corpus, and the information is extracted and stored in the database. For the honor part, after analyzing many teachers' honors, we have found that some verbs and nouns can represent the honor, as shown in the Table 4. The template is used to match the background corpus, the matched phrases are extracted and stored in the database, and then information is proofread to prevent duplicate of information.

Table 4. Template of honor.

Field template	Example
"excellent"/a "teacher"/n	Excellent teacher of new oriental education technology group
"editor-in-chief"/n	Editor-in-Chief of "Zhengheng" magazine
"prize"/n	High score prize
"obtain"/v	Received the new oriental outstanding teacher award

After obtaining university template and honor template, template-based matching in the background corpus is used to extract the required information. Since almost every corpus in this paper contain three attributes, the template-based information extraction technology can be used, and the efficiency of information extraction is high.

4.2 Construction of Knowledge Base

After the above text information extraction, we can get eight attributes of each teacher. Based on these attributes, we make a comprehensive analysis of teachers' teaching situation.

In this paper, a teacher's information is defined as a corpus. And the vector of a corpus is represented by five dimensions subject, teaching grade, educational background, teaching time and honor. Among them, subjects include English, Chinese, Mathematics, etc. Grades include junior 1, junior 2, junior 3 and senior 1, etc. Educational background includes bachelor, master, doctorate; The teaching time is normalized. Word of vector has been used to represent document in a matrix form, also can be used to generate the vector space model [17].

As shown in Table 5, for the characteristic value of subject, we stipulate that it is set to 1 when the value of subject in the corpus is Chinese, Math or English, and the other is set to 0. For grade, it will be known as junior high school when the value is the first, second, third in junior high school and senior high school entrance examination, and the value is set to 0. Senior 1, Senior 2, Senior 3 and College Entrance Examination collectively referred to as Senior High School, and set to 1. Some teachers are both junior high school teachers and senior high school teachers, we set these characteristics as 2. For teacher's educational background, bachelor is set to 1, master is set to 2, and doctorate to 3. Some teachers do not have educational background information and set the value of this type of teacher's educational background to 0. The value of teaching time is calculated from this equation of (time-min)/(max-min). For honors, the honored teacher has a value of 1, otherwise the value is set to 0. Here is an example, San Zhang, teaching subject is English, teaching grade is junior two, teaching time is 7300, education background is master and honor is Beijing new oriental outstanding teacher, so the vector of this corpus is (1, 0, 0.53, 2, 1).

Table 5. Eigenvalue vector analysis.

Eigenvalues		Process
Subject	Chinese&&Mathematics&&English	1
	Other	0
Honor	Received honor	1
	Other	0
Grade	Junior High School	0
	Senior High School	1
	All	2
Educational background	Bachelor	1
	Master	2
	Doctorate	3
	Other	0
Teaching time		(time-min)/(max-min)

The teacher's teaching situation is now divided into four categories, continued-maintenance, cheering, need to improve, and efforts to improve. If the score is between 5 and 10, it is the class of continued maintenance; the score between 4 and 5 is in the cheering category; if the score is between 2.5 and 4, it belongs to need to improve class; if scores between 0 and 2.5, it belongs to efforts to improve class. In the simulation experiment, we add the values of each dimension in the vector as the score, and in the real environment, the score is given by the judges. Based on score, each corpus is labeled manually.

4.3 Construction of BP Neural Network

It can be carried out in the next step that teachers' teaching situation prediction based on BP neural network according to the data obtained from the preprocessing. Construction of BP Neural Network is the Key Step, it is divided into the construction of the model and the adjustment of the parameters.

Construction Method of BP Neural Network. There must be an input layer, and an output layer in the network, and one or more hidden layers are required. At the same time, the number of neurons in each layer of the neural network needs to be determined. Activation function is an important part of BP neural network, which usually adopts S-type logarithm or tangent function. BP neural network designed in this paper adopts tansig activation function in both hidden layer and output layer, and its corresponding expression is shown in Eq. (1).

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

Parameters Adjustment. There are a lot of parameters in the BP neural network model, and the quality of parameter setting has a great impact on the prediction results.

Through the experiment of single hidden layer and double hidden layer, we have found that the effect will be better if we use double hidden layer. And we set the number of iterations to 600, the learning rate to be 0.01. The number of neurons in the hidden layer is determined according to the Eq. (2).

$$n_z = \sqrt{n_x + n_y} + m \tag{2}$$

The n_z refers to the number of neurons in the hidden layer, n_x and n_y refer to the number of neurons in the input layer and the output layer respectively, and m refers to a constant of zero to ten. The dimension of each corpus vector in the input layer is 5, the dimension of the classification is 1, so the number of neurons in the input layer is 6. The result of the output layer is the category, and the dimension is 1, so the number of neurons in the output layer is 1. When the corpus belongs to class of continued maintenance, the output result is 1. When the corpus belongs to class of cheering, the output result is 2. When the corpus belongs to class of need to improve, the output result is 3. When the corpus belongs to class of efforts to improve, the output result is 4. Through continuous experiments, the optimal number of neurons each hidden layer is determined to be 14.

5 Experiments

5.1 Experiment on Information Extraction

The corpus in this paper comes from the Internet. First, New Oriental is selected from various educational websites, because the website has rich teacher information, the URL is http://souke.xdf.cn/TeacherList.aspx of New Oriental. Then through the web crawler, we extracted relevant information about the teacher from the website.

In order to verify the effect of the constructed template, 612 corpus were manually labeled, and 312 corpus were used as training corpus. The template was continuously generalized and revised during the training process. The remaining 300 are used as test corpus. It can be seen from the result that template-based information extraction has a high accuracy. However, the automation level is low because templates need to be constructed manually and need manual participation in the process of generalization and continuous adjustment of the model. After extracting the required information, the results of verifying the effectiveness of the constructed template are shown in Table 6.

Table 6. Template inspection results.

Attribute category	Number(piece)			Percent (%)		
	Total	Identified	Correct	Precision	Recall	F1
University	155	132	128	96.97%	82.58%	89.20%
Degree	204	152	150	98.68%	73.53%	84.27%
Honor	97	65	54	83.08%	55.67%	66.67%
Summary	456	349	332	95.13%	72.81%	82.48%

The calculation method of Precision is shown in Eq. (3).

$$\Pr ecision(A,B) = \frac{|A \cap B|}{|A|} \tag{3}$$

The calculation method of Recall is shown in Eq. (4).

$$Recall(A,B) = \frac{|A \cap B|}{|B|} \tag{4}$$

A refers to the positive sample set of the model output, and B refers to the true positive sample set. The F1 value is an evaluation index that combines these two indicators, and F1 is shown in Eq. (5).

$$F1 = 2P * R/(P+R) \tag{5}$$

Prefers to the precision rate and R refers to the recall rate.

5.2 Experiment on BP Neural Network

The corpus is trained by the BP neural network designed above. There are 612 corpus in this paper, 412 of them were used as train samples, and the remaining samples were used as test samples.

When experiments are done with MATLAB, the results are shown in Table 7. The test corpus is 200 items, and the correct predictive result is 177 items, the correct rate is 88.5%.

Table 7. Experimental results.

Type	Number			Percent (%)		
	Total	Identified	Correct	Precision	Recall	F1
Efforts to improve	65	61	57	93.44%	87.67%	90.48%
Need to improve	60	57	49	85.96%	81.67%	83.76%
Cheering	41	46	38	82.61%	92.68%	87.36%
Continued maintenance	34	36	33	91.67%	97.06%	94.29%

The simulation result is shown in Fig. 2. Red is the real classification, and green is the classification of the prediction. It can be clearly seen from the figure that the contact ratio is high between the real result and the predictive result.

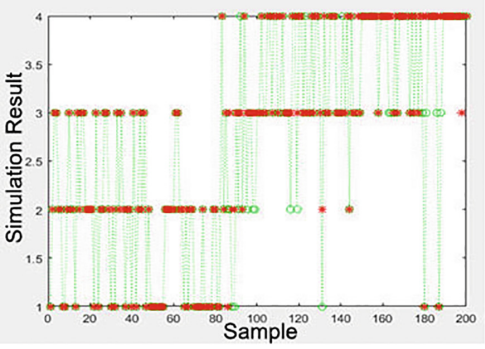

Fig. 2. Simulation result.

A graphical representation of the absolute error and the percentage error are shown as Fig. 3. The absolute error and the percentage error are 0 for most predicted samples, indicating that the neural network model has a higher correct rate.

When the experiment stops, Gradient Validation Checks, Learning Rate and the number of iterations are shown in Table 8.

As can be seen from the table, the experiment was stopped when the value of validation checks reaches 6. At this point, the error has reached the optimal, the error may increase or the phenomenon of over-fitting will appear if retraining, so when the value of validation checks reaches 6, the experiment was stopped. In this process, the optimal gradient is 0.036, the optimal learning rate is 1.315 and the number of iterations is 100.

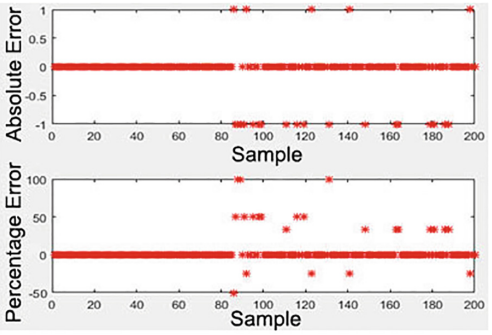

Fig. 3. Absolute error and percentage error.

Table 8. Attribute change.

Gradient	Validation checks	Learning rate	Epoch
0.313	6	0.051	131

MSE in BP neural network is used to test the performance of this network. The variation of the parameters and MSE during the experiment is shown as Fig. 4. From the figure, the gradient decreases at first, and then increases. In the process, the value of validation check reaches 5 from 3. When the number of iterations reached to 120, the value of validation check increased sharply to 6, and the experiment was stopped. The learning rate increased with the number of iterations and reached its maximum between 100 and 120. The performance of the network reached the best state when iterating to 124 times, and the MSE is 0.06 at this time.

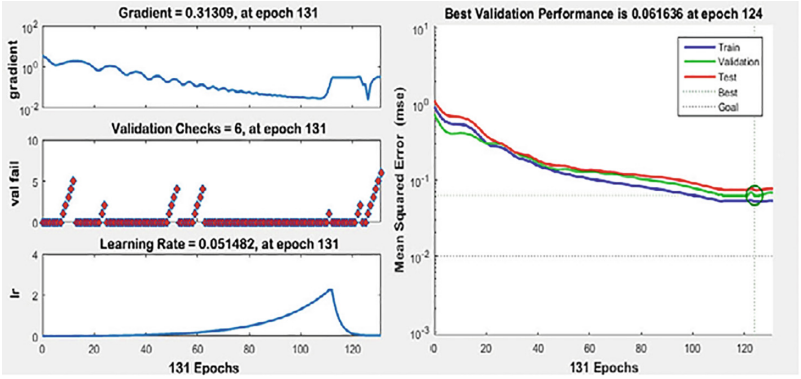

Fig. 4. Variation of the parameters and MSE.

In order to prevent over-fitting of data, BP neural network will divide the samples into training samples, validation samples and test samples. In these three parts, training samples is used to train, validation samples and test samples are used to test, and then regression analysis is carried out. The correlation coefficients at the end of the experiment is shown in Table 9.

Table 9. Correlation coefficient of regression test.

Training	Validation	Test	All
0.96	0.96	0.96	0.96

The change of the correlation coefficient during the experiment is shown as Fig. 5, in which the abscissa represents the true value of the classification and the ordinate represents the output value of the neural network. It can be seen that the correlation coefficient is very high, and the fitting curve is almost on the diagonal, thus the prediction accuracy is extremely high.

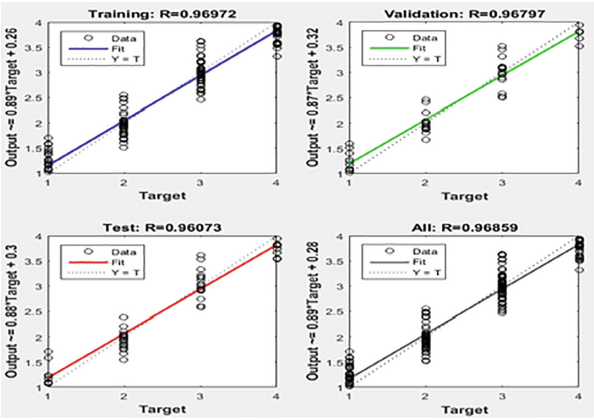

Fig. 5. Change of correlation coefficient during experiment.

6 Conclusion and Future Work

In this paper, through the analysis of the existing evaluation methods of teachers' teaching ability, we have found that there are great shortcomings. Based on this, this paper proposes a new and reasonable evaluation method of teachers' teaching ability. This method is based on BP neural network, extracts teachers' information through template, constructs knowledge base and trains neural network model, and finally evaluates teachers' teaching ability through classification. In the process of evaluating, the influence of individual factors on the results has been removed, which not only makes the evaluation process more reasonable, but also makes the evaluation more efficient.

In the future, we will consider the influencing factors of teachers' teaching ability more comprehensively. Based on this method, we can make a more objective evaluation of teachers' teaching ability in all aspects.

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