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English Teaching Quality Evaluation Model Based on the Combined Dempster–Shafer (DS) Theory and Support Vector Machine (SVM)

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Abstract

The English teaching quality evaluation model based on the DS-SVM is put forward aimed at the defect of scientific nature and low reliability of the evaluation results of current English teaching quality. First of all, from the perspective of information integration, construct the evaluation index system and adopt SAM to establish the evaluation models of English teaching quality in view of the students, the counterparts and the supervisor group. Then, determine values of the reliability function of each model by virtue of SVM. Finally, obtain the evaluation results of current English teaching quality through the combination of DS and values of the reliability function. The simulation experiment results show that output value from this English teaching quality evaluation model agrees well with the true value and is of better evaluation effectiveness.

Keywords: *Dempster–Shafer Theory, Support Vector Machine, Teaching Quality Evaluation, English Teaching*

1. Introduction

How to enhance accuracy and scientific nature of the evaluation results of teaching quality and provide the education managers with decision-making reference has become the important subject in the research of higher teaching management [1].

Teaching quality evaluation is a multi-objective and multi-level evaluation problem [2, 3], of which the methods can be divided into two types: statistical method and machine learning method. The former mainly includes analytic hierarchy process, cluster analysis method, entropy method *etc*. With a complex non-linear relation existing between university teaching quality evaluation index and evaluation results, it is difficult to set up a scientific and reasonable mathematical model with these methods, therefore the evaluation is of low accuracy and unbelievable results [4]. Machine learning algorithms primarily contain nonlinear methods, such as neural network and SVM [5, 6], which can give a better description on the non-linear relation between evaluation index and evaluation results. In particular, the SVM based on structural risk minimization, with high generalization ability, can maximize the existing information, which has been proven to be the main researching direction for current teaching quality, thus being selected for the establishment of evaluation model of the teaching quality [7]. As for the teaching quality

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built on SVM, evaluation data from the supervisor group, the students and the counterparts are firstly modeled prior weighting them and then the comprehensive evaluation results of teachers' teaching quality are gained [8]. At present, each sub-model is weighted linearly in an artificial manner, for which the evaluation results are of strong subjectivity. In this case, the scientific nature of evaluation results for the teaching quality is affected. In terms of reasoning algorithms, the evidence theory can bring relatively accurate reasoning process and results. Being outstanding in decision-making, it can apply knowledge from multiple experts and data source in tandem, and ultimately prevent the subjective factors in that the reasoning and decision-making abilities can adapt to the weights of different evaluation models for teaching quality.

The DS-SVM is proposed in this paper with the purpose of promoting scientific nature and reliability of the teaching quality evaluation results. From the standpoint of information integration, construct the evaluation index system and adopt SAM to establish the teaching quality evaluation models based on students, counterparts and supervisor group. Then, output value of the reliability function of each model by virtue of SVM. Finally, obtain the evaluation results for current English teaching quality through the combination of DS and values of the reliability function. The simulation experiment results show that DS-SVM can exactly illustrate the non-linear relation between teaching quality evaluation and evaluation results, which not only raises the reliability of teaching quality evaluation results, but reflects the teachers' teaching competence.

2. Correlation Theory

2.1. SVM

Assume the sample number of training set is n and the training set can be expressed by: $\{X(i), y(i), i=(m-1)\tau, \cdots, n-1\}$, $X(i) \in R^m$, $y_i \in R$. With the aid of nonlinear mapping function $\varphi(X)$, the input samples are mapped to the high-dimensional feature space F by SVM and estimated linearly in F. The estimating function for SVM in high-dimensional feature space is:

$$f(x) = w \cdot \varphi(x) + b \ , \tag{1}$$

Wherein, *w* and *b* refer to weight vector and offset respectively.

$$\begin{aligned} W(\alpha, \alpha^*) &= -\frac{1}{2}\sum_{i,j=1}^{n}(\alpha_i - \alpha_i^*)(\alpha_j - \alpha_j^*)(\varphi(x_i), \varphi(x_j)) \\ &\quad + \sum_{i=1}^{n}(\alpha_i - \alpha_i^*)y_i - \sum_{i=1}^{n}(\alpha_i - \alpha_i^*) \\ s.t. & \\ &\begin{cases} w = \sum_{i,j=1}^{n}(\alpha_i - \alpha_i^*)x_i \\ \sum_{i=1}^{n}(\alpha_i - \alpha_i^*) = 0 \\ 0 \le \alpha_i, \alpha_i^* \le C \end{cases} \end{aligned} \tag{2}$$

Adopt the kernel function K(xi,x) to take place of the inner product of vectors (φ(xi),φ(x)) in high-dimensional space in avoidance of the curse of dimensionality, and the decision function for SVM is:

$$f(x) = \sum_{i=1}^{n} (\alpha_i - \alpha_i^*) k(x_i, x) + b \tag{3}$$

2.2. Evidence Theory

The evidence theory is firstly proposed by Dempster, on which basis Shafer perfect the theory, therefore it is called the DS Theory. The evidence theory is one belief function integrated from two or more evidence bodies through combination rules.

Assume the detection framework is Θ, so define the function m: 2Θ→[0,1] and make the function m:2Θ→[0,1] satisfy the following conditions: $m(\varnothing) = 0$, ($\varnothing$ is empty set), $\sum m(A) = 1$ ($A \in 2^{\Theta}$). Assume m(A) is called as the BPA in framework Θ with BPA referring to basic probability assignment. Therefore, when A≠Θ, m(A) can be used to present the accurate trust degree of proposition A. Meanwhile, the uncertainty of evidence is expressed by m(Θ).

The combination rules can be defined as: basic probability assignments (BPA) of various evidences in detection framework Θ are m1, m2, …, m_n, and the orthogonal sum is $m = m_1 \oplus m_2 \oplus \cdots \oplus m_n$ which can be determined as:

$$m(A) = \frac{\sum_{B \cap A_i = A} \sum_{j=1} m_j(A_i)}{1 - \sum_{B \cap A_i = \varnothing} \sum_{j=1} m_j(A_i)} \tag{4}$$

3. DS-SVM Teaching Quality Evaluation Model

3.1. Working Framework for Teaching Quality Evaluation Model

Divide the whole dataset into three samples: student, counterpart and supervisor group and then build up the teaching quality evaluation model based on SVM for each type of sample. The evaluation indices are mapped to evaluation results by SVM, which contribute to increase the teaching quality evaluation efficiency. Meanwhile, structure the evaluation layer of teaching quality with these three types of SVM, consider the evaluation results as one evidence body coupled with the evidence theory and acquire the teaching quality evaluation results to improve the evaluation accuracy. In this case, the inferential capability of DS theory and the capability of nonlinear approximation of SVM are comprehensively utilized, which plays their respective advantages and the teaching quality evaluation model in view of DS-SVM is shown in Figure 1. The model falls into two layers: ①Result layer of preliminary evaluation for teaching quality based on SVM; ②Decision layer integrated with evidence theory and SVM.

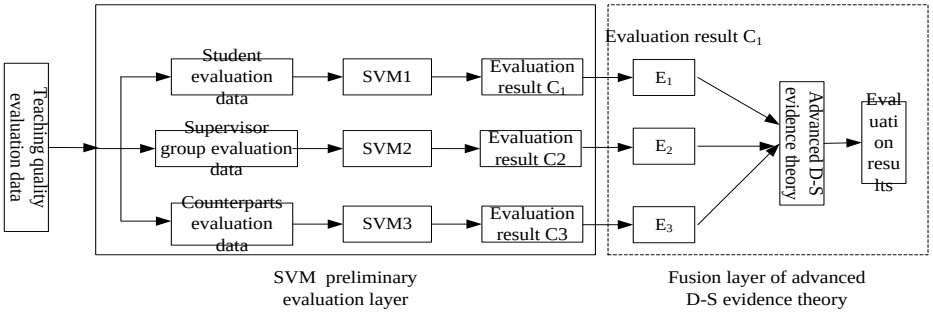

Figure 1. Working Framework for Teaching Quality Evaluation Model based

on DS-SVM

3.2. Establish the Teaching Quality Evaluation Index System

The first step for teaching quality evaluation model is to construct the corresponding evaluation factor set (index system).Whether the index system is scientific and rational is directly related to its scientific nature and rationality. However, the teaching quality evaluation is subject to various factors, such as teaching method, teaching attitude, teaching contents, classroom management and teaching efficiency. Through systematic analysis and expert commentary, and taking the relevant documents and research as reference [10, 11], teaching quality evaluation system is built in this paper as shown in Table 1. This index system manifests the teachers' teaching process to a certain extent. The evaluation on teachers' teaching can be presented by marking the evaluation of indices, from which it is recognized to which type the teachers' teaching quality belongs, and the teaching quality is promoted. Wherein the teachers' quality (B1), the teaching attitude (B2), the teaching contents (B3), teaching method (B4) and the teaching efficiency (B5) worth 20 points respectively.

Table 1. Teaching Quality Evaluation Index System

First grade index	Second grade index
teachers' quality	Be of good teaching skill (x_1)
	Be highly knowledgeable in the teaching subject (x_2)
	Be of strong capacity for scientific research (x_3)
	Be of appropriate teaching characteristics (x_4)
teaching attitude	Be serious and responsible for teaching (x_5)
	Obey regulations and disciplines of the school (x_6)
teaching contents	The course content is correct and reasonably designed (x_7)
	Be able to teach the students in accordance of their aptitude (x_8)
teaching method	The teaching methods are flexible and diverse, rational and effective (C_9)
	The teaching is inspirational and can stimulate interest in learning (C_{10})
teaching efficiency	The students acquire necessary knowledge about the subject and general curriculums (x_{11})
	The students acquire somewhat learning ability and are of improved capability in solving practical problems with theoretical knowledge (x_{12})

3.3. Determine the Weights with Analytic Hierarchy Process (AHP)

It is imperative to confirm the weights of indices in the middle of teaching quality evaluation, which will affect whether the evaluation results are reliable or not. With the decision-related elements being disintegrated by AHP into target, criterion, scheme *etc*., conduct the qualitative and quantitative analysis, delete the subjective components as much as possible by virtue of mathematical logical reasoning and make the weights in conformity with the practical situation. Above all, construct the judgment matrix in criterion layer through pair-wise comparison. Then calculate the maximum eigenvalue of matrix $\lambda_{\max}$. Finally evaluate the eigenvectors of maximum eigenvalue prior to normalizing them and then each index weight ω is obtained. The judgment matrices may not be consistent due to people's subjective judgment on importance elements. Therefore, the formula below is needed to test the consistency and randomness after the weights are calculated.

$$\begin{aligned} CI &= (\lambda_{\max} - n)/(n-1) \\ CR &= CI / RI \end{aligned} \tag{5}$$

Wherein, *CI* refers to the index of consistency of the judging matrix; $\lambda_{\max}$ refers to the maximum eigenvalue of matrix; n refers to the order of matrix; *CR* refers to the mean

random consistency ratio in the same order. The values of *CR* in 1-9 order of the judging matrix are shown in Table 2. When *CR*<0.10, it indicates that the judging matrix is of satisfactory consistency, otherwise the matrix data is in want of adjustment.

Table 2. The Consistency Index of the Average Random

order	1 2	3	4	5	6	7	8	9
RI	0 0	05 2	0.8 9	1.1 2	1.2 6	1.3 6	1.4 1	1.4 6

According to the theory of hierarchical analysis, combining with the actual of teaching quality evaluation, it is divided into 4 levels. The quality of teaching is the target level A, one-level indicator is the criterion level B, second level indicators is the sub criteria layer of C, the teacher to be evaluated is the scheme layer P. For an old teacher, teaching experience and the degree he is familiar with a certain subject should reach a certain level, and at present new teachers of universities are highly educated, strong research ability making up for the lack of experience, so the quality of teachers should be ranked at the end in the important factors of teaching quality, while the teaching attitude slightly important than it, for the quality of classroom teaching, teaching content is important than teaching attitude, and a good way attracts the attention of students and help students absorb knowledge, so the teaching method is important than the teaching content, the reflection of high teaching quality is that the students' obtain of knowledge and the improvement of students' ability, so the teaching effect should be the most important index in the teaching quality evaluation. Therefore, the importance of the quality of teachers, teaching attitude, teaching content, teaching method, teaching effect of one-level indicator increases in turn, comparing the criterion level (one-level indicator) to construct Judgement Matrix , one-level indicator and weight value as shown in Table 3.

Table 3. One-level Indicator and Weight Value

A	B_1	B_2	B_3	B_4	B_5			*CR*
B_1	1	1/3	1/5	1/7	1/9	0.0333	5.2375	0.0530<0.1
B_2	3	1	1/3	1/5	1/7	0.0634		
B_3	5	3	1	1/3	1/5	0.1289		
B_4	7	5	3	1	1/3	0.2615		
B_5	9	7	5	3	1	0.5128		

In like manner, construct the judgment matrix of the sub criteria level, and calculate the weight of each second level of the sub criteria level,

$$\begin{cases} \omega_{B1} = (0.56, 0.27, 0.11, 0.06) \\ \omega_{B2} = (0.75, 0.25) \\ \omega_{B3} = (0.64, 0.26, 0.10) \\ \omega_{B4} = (0.75, 0.25) \\ \omega_{B5} = (0.61, 0.27, 0.12) \end{cases} \quad (6)$$

3.4. The Working Process of the Model of the Evaluation of DS-SVM Teaching Quality

(1) Firstly, using the support Vector Machine (SVM) to evaluate the teaching quality of students, colleagues, the steering group, to get the corresponding results of teaching quality evaluation.

(2) structure evidence. Take every output of evaluation result of support vector machine as an evidence, then the output of support vector machine becomes:

$$P(y=1 \mid x) \approx P_{A_S, B_S}(g) = \frac{1}{1+\exp(A_S g + B_S)} \tag{7}$$

In the formula, AS and BS ais the posteriori probability; g is the output of SVM.

By the method of maximum likelihood to calculate AS and BS, and then use the training set to study, to obtain the corresponding accuracy of evaluation RI, then the BPA function can be defined as:

$$m_i(A_j) = p_j r_j \tag{8}$$

(3) The results of teaching quality evaluation fuse the final decisive result. The process of calculation: Calculating the (6) formula to get its reliability, and then bring into (4) to calculate the combined reliability of the remaining evidence, altogether, getting the results of teaching quality evaluation. There are four decision rules:

①Taking the class with maximum reliability as the target class;

②The difference of the assigned values (reliability and reliability of uncertainty of target class) is greater than a certain threshold (ε2);

③The difference of the reliability (the target class and other class) must be greater than a threshold (ε1);

④The assignment value of the uncertainty of reliability should be less than a certain threshold (ε3).

4. Experimental Results and Analysis

4.1. Data Sources

In order to verify the performance of teaching quality evaluation model proposed in this paper, realizing in CPU P4 2.8 GMHZ, RAM 2GB, operating system of Windows 2000z, RAM 1 GB PC machine and VC++ software platform. The experimental data came from 1000 evaluation data of students of the course of computer network technology of Sichuan Neijiang Normal University, peers and steering group, each kind of data is divided into training set and test set by 4:1. Part of the evaluation data of students as shown in Table 4.

Table 4. The Data of Teaching Quality Evaluation of Students

Number	x_1	x_2	x_3	…	x_{12}	y
1	92.65	95.52	78.91	…	92.25	92.05
2	74.66	83.26	90.79	…	74.29	87.15
3	91.02	95.18	83.16	…	90.85	91.66
4	63.96	96.67	77.18	…	64.46	73.90
5	76.34	77.34	57.35	…	76.05	67.69
6	77.72	94.58	95.01	…	78.36	99.59
7	78.51	89.42	89.84	…	78.82	95.00
8	87.59	81.48	80.66	…	87.81	88.47
9	39.16	50.72	47.72	…	38.98	76.50
…	…	…	…	…	…	…

4.2. Data Preprocessing

For the index of this paper is reflected by students grades, but because of the outline amount of each instruction is not the same, the difference of data is large, but the

difference of sample data is too large or too small may increase the computational complexity and lengthen training time. Therefore, we need to normalize the data, making it into the closed interval [0, 1], the specific formula of normalization such as (9):

$$x_i^{'} = \frac{x_i - x_{i\min}}{x_{i\max} - x_{i\min}} \quad (9)$$

In the normalized formula (9), the I index expressed by Xi, the minimum and maximum values of the I index of are indicated by x_{imin} and x_{imax}, the final results of normalization is expressed by $x_i^{'}$.

4.3. SVM Preliminary Evaluation of Teaching Quality

The evaluation data of students, the evaluation data of steering group, the evaluation data of peer are input the SVM to learn, using 10-fold cross-validation to choose the parameter of SVM, and then establish multiple evaluation model, the evaluation subjects are students, steering group, peer, based on evaluation model to synthesize the evaluation model of teaching quality, the results got by evaluation that taking the experimental data as test set as shown in Table 5. From Table 5 we can get that, it is difficult to describe the evaluation of teaching quality accurately, comprehensively by using the evaluation data of students, the evaluation data of steering group, the evaluation data of peer, the precision of evaluation is relatively low, the result is not reliable.

Table 5. Preliminary Evaluation Results of SVM Teaching Quality

Evaluation model	precision of the evaluation
Evaluation model of students	78.89
Evaluation model of steering group	72.05
Evaluation model of peer	76.67

The decision threshold of decision rules is respectively$\varepsilon 1=0.65$，$\varepsilon 2=0.45$，$\varepsilon 3=0.35$, the calculation of the various features and the function of the reliability according to it, see Table 6.

Table 6. The Detection Framework of the Value of Reliability

Evaluation model	$m(A_0)$	$m(A_1)$	$m(\Theta)$
Evaluation model of students	0.35	0.52	0.57
Evaluation model of steering group	0.23	0.37	0.49
Evaluation model of peer	0.40	0.64	0.38

4.4. The Evaluation Results of DS-SVM

According to the reliability values using the DS to synthesize the evaluation model of students, the evaluation model of steering group, the evaluation model of peer, the results of the output of actual and the output of model as shown in Figure 2, the actual output values are obtained by expert scoring, the correlation coefficient of the actual output and the model output is 0.9855, the correlation coefficient between the actual output and the the output of the model representing the fitting precision, thus the evaluation accuracy is up to 95.15%, the precision of the evaluation results is very high, the results show that, the evaluation method of synthesizing the evidence theory and support vector machine that evaluate teaching quality is effective and feasible.

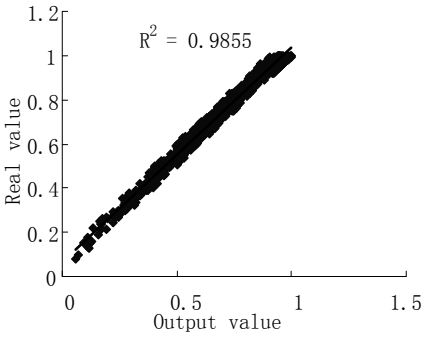

Figure 2. The Actual Output and the DS-SVM Correlation Curve

4.5. Compared with the Results other Evaluation Model

To evaluate the quality of DS-SVM model, choosing DS-BP neural network (DS-BPNN), the traditional weighted combination model, the DS-BPNN, the relative variation curve between the actual output of the traditional weighted combination model and the output of model as shown in Figure 3~4, the evaluation of model performance is shown in Table 7. Comparing and analyzing simulation results of Table 7 and Figure 3~4, we can draw the following conclusions:

(1) The evaluation results of DS-SVM is better than the evaluation results of DS-BPNN, this is mainly due to the support vector machine based on the principle of the minimization of structural risk, overcoming the shortcomings of neural network fitting, slow convergence speed and so on well, can describe the complex non-linear relationship between the evaluation index of teaching quality and evaluation results well, therefore, we can obtain more ideal evaluation result of teaching quality.

(2) The DS-SVM evaluation result is superior to the traditional combined model, mainly due to the traditional combined model taking combination through the linear weighted on index, it is difficult to describe the nonlinear relation between index and the output results, so the deviation between the evaluation value and the actual value is large, and the evaluation results of DS-SVM using reliability assignment of SVM DS structure of evidence theory, according to the rule of evidence combination that synthesized the teaching evaluation results from students, steering group, peers, it can be clearly distinguished contribution of each model to the final evaluation results, and improve the precision of the evaluation of teaching quality, and the evaluation results are more scientific, credible.

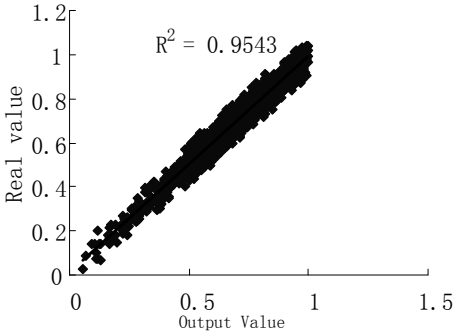

Figure 3. The Correlation Curve between the Actual Output and DS-BPNN Output

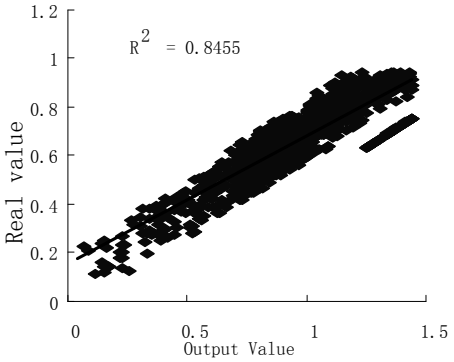

Figure 4. The Correlation Curve between the Actual Output and the Output of Traditional Combination Model

Table 7. Comparison of Model Performance Evaluation

Evaluation model	precision of the evaluation(%)	The correlation coefficient
the traditional combined model	91.16	0.8455
DS-BPNN	93.22	0.9544
DS-SVM	95.15	0.9855

5. Conclusion

The evaluation system of teaching quality is a complicated nonlinear system, having a lot of uncertain factors between the input and the output, therefore, this paper puts forward a kind of evaluation method of the teaching quality that fusing evidence theory and support vector machine. The simulation results show that, the output value of teaching quality evaluation model established in the paper is in good agreement with the real value, the error of the evaluation result is smaller, and can meet the requirements of the practical application of the evaluation of teaching quality, can be expected to provide beneficial reference to teaching management departments on seeking a scientific solution of evaluation of teaching quality. The evaluation of teaching quality is a system engineering, there is a controversial research topic, the theoretical research and applied research of this thesis is still at the starting stage, there are still many problems to be solved, such as if the student being not considered it is difficult to evaluate the ability of scientific research of teachers, how to use more scientific analyzed method to choose right sample data and determine reflecting the essential, typical and objective index remains to be further researched and discussed.

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