Journal of Education and Praxis Research. Volume 3, Issue 1, (2017) 12-18
http://www.cayley-nielson.com/jepr

Evaluating English Education Based on BP Neural Network

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Abstract

English course education performance management plays a key role in training innovative students for universities, and how to evaluate English course education performance is one of the difficulties and hot research fields for the researchers related. The paper presents a new model for evaluating English course education performance based on improved BP neural network. First an evaluation indicator system of English course education performance is designed through the aspects of university regulation and teachers and students and education effects; Second, aiming at the shortages of the existing BP neural network algorithm of data-mining for evaluating English course education performance, BP neural network algorithm is improved through adjusting dynamic strategy and the value of momentum factor to speed up the convergence and simplify the structure and to improve evaluating accuracy of the original BP model. Finally the experimental results show that the new evaluation indicator system and improved BP neural network algorithm can be used practically in evaluating English course education for different universities and guarantee the evaluation effectiveness and validity.

Keywords: Education performance management, English education performance evaluation, BP neural network, Dynamic strategy of momentum factor

1. Introduction

To implement overall quality education in university education and cultivate students' practical ability and innovative spirit has become the overall trend of higher education at home and abroad currently. Accordingly, in recent years, universities in the country have also launched the construction and practice of English ability training system for university students, having explored and implemented some typical university English course education patterns. Meanwhile, education evaluation has also been developed into an important driving force and control measure for higher education. On this basis, how to effectively carry out scientific evaluation on university students' inquiry learning and innovative ability training (scientific theory, method and standard required) becomes a problem with practical significance, also a research hotspot in and out of the industry [1-5].

2. Analysis and establishment of evaluation indicator system

While designing the indicator system of English course education evaluation of higher institutions, this thesis first takes the English course education of higher institutions as characteristic. Higher education being a teaching activity transferring advanced knowledge and training senior professional talents, English course education job in higher institutions, besides having the common characteristics of higher education job and common rules to be obeyed, has features different from ordinary education

ISSN 2378-9654 /
March, 2017

process. Therefore, this thesis first refers to literatures related to English course education and experts' opinions, according to relevant principles of education and surveying, deciding the scope of influence of English course education in higher institutions by combining area method with goal method, and designing evaluation indicator system with such four perspectives of English course education job as schools, teachers, students and effects. The system includes 4 first-grade indicators, 12 second-grade indicators, 35 third-grade indicators, see table 1 with more details.

Table 1. Evaluation indicator system of English education performance

Target Hierarchy	First-grade Indicator	Second-grade Indicator	Third-grade Indicator
Evaluation on English Education in Higher Institutions	Universities	System Construction	Plan Making Management System Evaluation System
		Implementation Organizing	Plan Implementation Management Implementation Evaluation Implementation
		Funds and Personnel Input	Management Team Construction of Teachers Construction of Teaching Materials
		Construction of English Base	Base Construction Base Construction Planning
		Education Concept	Emphasis put on English Education
		English Culture Atmosphere in Campus	Academic Atmosphere English Atmosphere
	Teachers	English Education Ability	Teacher-Student Ratio of English Education English Guiding Ability Theoretical English Ability Practical English Ability
		English Education Concept	English Education Motivation Course System of English Education Course Contents of English Education Off-campus English Education
	Students	Receptivity of English Education	Enrollment Quality of Students Self-learning Ability Practical Ability
		English Education Learning	Learning Method Learning Effect Learning Motivation
	Education Effects	Increasing of Students' Innovative Ability	Participation Enthusiasm of Off-campus Scientific Activities Awards of English Competition Professional Skill Creative Skill Work Motivation
		School English Education Effects	Theoretical Achievement of School English Education Practical Achievement of School English Education

3. Applicability of BP algorithm to the teaching quality evaluation

Teaching is a dynamic process integrating instructing and learning. There are lots of factors influencing teaching quality, and the influences of these factors are different; therefore, it is difficult to express the evaluation result with a mathematical formula. It is a non-linear classification problem, which brings huge difficulty in comprehensive evaluation. In the previous evaluation systems, the mostly adopted method is to directly establish mathematical model of evaluation system, such as weighted average method, analytic hierarchy process, fuzzy comprehensive evaluation method, all of which are hard to get rid of various randomness and subjectivity in the evaluation process, easy to cause the distortion and deviation of evaluation results.

Neural network technology [6-9], in the aspects of pattern recognition and classification, recognition filtering, automatic control and forecast, has shown its extraordinary superiority. The occurrence of artificial neural network provides a new way for the teaching quality evaluation of higher institutions. Through continuous learning and training, artificial neural network is able to find its regularity among huge quantities of complicated data of unknown mode, especially able to process data of any type, which is unparalleled compared with many traditional methods. Hence, to apply the theory of artificial neural network to the classroom teaching quality evaluation system of higher institutions not only solves the problems of qualitative indicators and quantitative indicators in comprehensive evaluation indicator system, conquers the problems of establishing complicated mathematical model and mathematical formula in traditional evaluation process, but also avoids the subjectivity of humans, making the evaluation more accurate and effective; to make use of the mathematical model of classroom teaching quality evaluation system established by neural network theory is an effective way to evaluate teaching quality.

3.1 Working principle of BP algorithm

Up till now, hundreds of artificial neural network models are put forward from different views of research, among which multi-hierarchy feed forward error back propagation BP neural network is the most-widely used network model in actual research. Basic three-layer BP neural network structure is shown as Picture 1.

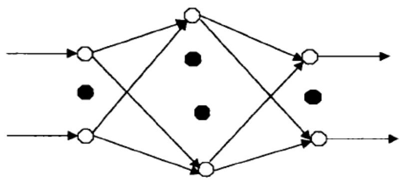

Figure 1. Basic structure of BP neural network

From the picture we can see that three- layer BP neural network is mainly comprised of input layer, hidden layer and output layer. Adjustable weight ω connects the layers. There can be several hidden layers, forming multi-layer BP neural network. The input of BP neural network is recorded as $x_i(k)$, the actual output of network is recorded as $y_j(k)$, the ideal output of network is recorded as $Y_i(k)$, the subscripts i, j indicate the nodes of input layer of network respectively, and k is the running iterations of BP neural network. Its approximation error is defined as Formula 1 in which L is the quantity of output layer nodes; in this way, the function characteristic of BP neural network can be described as formula 2.

$$E = \frac{1}{2}\sum_{j=1}^{L}(Y_j(k) - \gamma_j(k))^2 \tag{1}$$

$$\gamma_j(k) = f(x_i(k), \omega) \tag{2}$$

In formula 2, function f is obtained through the composition of weights of each network layer and node function, generally being very complicated non-linear function BP neural network training is to dynamically adjust the connecting weight ω to make formula 3 workable. The learning of weight ω adopts the fastest grads descent principle, i.e. the variable quantity of weights is in proportion to the negative gradient direction of approximation error E. See reference 2 for specific calculation.

$$\lim_{k\to\infty} E = \lim_{k\to\infty} \frac{1}{2}\sum_{j=1}^{L}(Y_j(k) - \gamma_j(k))^2 = 0 \tag{3}$$

3.2 Algorithm improvement in adjusting the value of momentum factor α

The introduction of momentum is, in essence, to exert a recursive low pass filter on $\partial E_{all} / \partial(\bullet)$, so as to "attenuate" the error of "high-frequency oscillation" and expand the "direct current" component of error gradient along "the bottom of canyon"; secondly, the investigation of iterative correction formula of network parameter (one of the parameters representing ω, θ, S) can be expressed by formula 4.

$$\begin{aligned}\bar{X}(k) &= \bar{X}(k-1) - \eta(k-1)\frac{\partial E_{all}}{\partial \bar{X}(k-1)} + \alpha\Delta \bar{X}(k-1) \\ &\approx \bar{X}(k-1) + \eta(k-1)\{-\frac{\partial E_{all}}{\partial \bar{X}(k-1)} + \frac{\alpha\eta(k-2)}{\eta(k-1)}(-\frac{\partial E_{all}}{\partial \bar{X}(k-2)})\}\end{aligned} \tag{4}$$

The above parameters are expressed by vectors, which shows that the introduction of momentum makes the approximation similar to the conjugate gradient search process, but $\frac{\partial E_{all}}{\partial \bar{X}(k-1)}$ and $\frac{\partial E_{all}}{\partial \bar{X}(k-2)}$ are not in the form of conjugate gradient; in these circumstances, the value of momentum factor α can be adjusted as follows.

While the learning errors of recent continuous S' times are increasing, $\alpha = 0$, stop the amplified action on "direct current component";

Otherwise, the value of α keeps unchanged, maintaining the restrain on "high-frequency oscillation".

Generally, as there are change points of learning speed in "oscillation area" in error curved surface, in order to avoid the over slowness of learning process towards "oscillation area", the value α shall not be too big; [0.1-0.3] will be appropriate.

4.3 Algorithm improvement in dynamic strategy of momentum factor α

Stagnation is the fundamental cause resulting in the inadequacy of BP neural network algorithm. Based on the deterministic and random selections, this paper adjusts the transition probability dynamically to build the selection strategy more conducive to the overall search.

The pheromone in the path occurs continuous change in the evolutionary process. The pheromone of better solution searched is strengthened to increase the selection possibility of next iteration, and some better solutions is forgotten gradually because fewer ants pass in the start-up phase so as to affect the overall search capabilities of the algorithm. If the BP neural network are stimulated properly to try the path occasionally in the selection strategy, it is conducive for the overall search of the solution space. Thus, the inadequacy of basic BP neural network algorithm is overcome effectively. See formula 5 for the improved selection strategy in this paper.

$$P_{ij}^{k}(t)=\begin{cases}\arg\max\{\left|\tau_{ij}(t)\right|^{\alpha}\cdot\left|\eta_{ij}(t)\right|^{\beta}\}, & q\le q_0,\ j\in allowed_k;\\ \dfrac{\left[\tau_{ij}(t)\right]^{\alpha}\cdot\left[\eta_{ij}\right]^{\beta}\cdot X_{ij}(t)}{\sum\limits_{k\in allowed_k}\left[\tau_{ik}(t)\right]^{\alpha}\cdot\left[\eta_{ik}\right]^{\beta}\cdot X(t)}, & j\in allowed_k, others\end{cases} \tag{5}$$

In formula 5, X_{ij} meets the requirements of formula 6.

$$X_{ij}=\frac{m\cdot N_c}{m\cdot N_c+\delta\cdot Q_c(i,j)\cdot\eta(i,j)/\max\eta} \tag{6}$$

In frmula 8, m is the number of ants, N_c is the number of current iterations, $\max\eta$ is the maximum of heuristic function $\eta(i,j)$,and $Q_c(i,j)$ is total number of BP neural network in the current path (i,j) from the first iteration. Q_c and η are considered in X . When previous iteration tends to suboptimal solution, the number $Q_c(i,j)$ of BP neural network increases and its X value decreases constantly in spite of constant increase of the pheromone in the suboptimal solution. Therefore, another selection of the path can restrain the excessive increase of the pheromone to cause premature convergence, and is conducive to global convergence.

4.4 Adaptive change of algorithm step

In order to make the learning step better carry out adaptive change, adjustment shall be carried out according to different conditions. Specific change steps are as shown below.

Under the guiding of non-monotone linear search method, calculate the error change of forward and backward iteration process

$$\Delta E_{all}(k)=E_{all}(k)-\max_{0\le i\le r_g}\{E_{all}(k-i)\} \qquad \Delta E_{all}(k-1)=E_{all}(k-1)-\max_{0\le i\le r_g}\{E_{all}(k-i)\} \tag{9}$$

If the learning errors of recent continuous S times are decreasing, the step change is formula 10n which $\beta_1\ge 1$; if the learning errors of recent continuous S times are increasing, the step change is formula 11n which $\beta_2\le 1$; otherwise, time varying coefficient L needs to be calculated through formula 12

$$\eta_k=\beta_1*\eta_{k-1} \tag{10}$$

$$\eta_k=\beta_2*\eta_{k-1} \tag{11}$$

$$L(k)=C1*\frac{-\Delta E_{all}(k)}{E_{all}(k-1)}+C2*Sgn(-\Delta E_{all}(k))*\frac{|\Delta E_{all}(k)-\Delta E_{all}(k-1)|}{|\Delta E_{all}(k-1)|} \quad (12)$$

If $\Delta E_{all}(k-1)=0$, then take the first item only; if $L(k)\geq \beta 1\text{-}1$, then $L(k)=\beta 1\text{-}1$, if

If $L(k)\leq \beta 2\text{-}1$, then $L(k)=\beta 2\text{-}1$. Based on this, step change is formula 13.

$$\eta_k=(1+\mathrm{L(k)})*\eta_{k-1} \quad (13)$$

In the above formulas, k represents learning times, $E_{all}(k)$ is the error after the kth times of learning (define according to Cauchy error estimation form), Sgn (●) represents sign function, η is learning step, s, S, $C1$, $C2$ are predetermined constants.

The essence of the above step change strategy is to change the step according to the features of “flat area” and “oscillation area” of error curved surface: the increase and decrease of step in “oscillation area” are adjusted with the percentage of forward and backward error change, so the learning process can be better closed to “optimal route”; while in the “flat area”, rapid increase and decrease shall be implemented on step to accelerate the convergence of learning process. Therefore, in the actual calculation of this thesis, the value of β_1 is among [2,4], and the value of β_2 is among [0.1,0.4].

5. Experiment confirmation

Experimental data come from database of A University, B University and C University. Relevant data of 3000 learner of each university are selected as the basis for data training and experimental verification in the paper, totally 9000 learns’ data for study data that come from practical investigation and visit of different students. In order to make the selected learners’ data representatives, 1200 learners(400 learner from each university) with more than 3 years learning experience, 6000 learners with 2 years learning experience, 1800 learners with less than 2 years but more than one year’s learning experience. Limited to paper space, the evaluation of intermediate results is omitted here, only providing evaluation results of first grade indicators and final comprehensive evaluation results in table 1 and evaluation results of second grade indicators taking the first grade indicator of schools for example in table 2.

Table1. Evaluation results of first grade indicators

	A University	B University	Shanghai Normal University
Schools	4.237	4.007	4.113
Teachers	4.531	3.961	4.496
Students	4.519	3.772	4.343
Education Effects	4.358	3.783	4.178
Final evaluation	4.463	3.802	4.276

Table 2. Part evaluation results of second grade indicators

	Peiking Normal University	Shangxi Normal University	Shanghai Normal University
System Construction	4.211	3.991	4.188
Implementation Organizing	4.361	3.971	4.017
Funds and Personnel Input	4.387	3.671	4.003
Construction of English Base	4.158	4.103	4.116
Education Concept	4.265	4.081	4.171
English Culture Atmosphere in Campus	4.411	4.399	4.392

6. Conclusion

This thesis, from the perspectives of schools, teachers, students and English course education effects, designs a set of efficient English course education evaluation system, and puts forward an evaluation model on the basis of BP neural network method based on analyzing the advantages and disadvantages of all the evaluation methods. Test results show that model in this thesis has favorable practicability and evaluation accuracy. This thesis considers that it is the next research direction to further decrease the interference of artificial evaluation results and guarantee the intelligence of evaluation process.

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