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An Improved Self-Organizing Feature Maps Algorithm and its Application in Arts Course Teaching Evaluation

Zhi Lin
School of Art and Design, Jiangxi Science and Technology Normal University, 330038, Nanchang, Jiangxi, China

ABSTRACT

Self-organizing feature map algorithm is one of the most important types of unsupervised learning method based on neural network technology but it tends to get stuck in local minima and yield the topological defect problem which limits its practical usage. Based on K-means algorithm, the paper presents a new self-organizing feature map algorithm to simplify its algorithm structure and speed up its calculation. First, a new simplified calculation structure is designed for the new algorithm based on analyzing working principle of self-organizing feature map algorithm; Second the presented algorithm combines self-organizing feature map algorithm and K-means algorithm and presents some improvements including redefining the information representation method and distance between two seeds and redesigning new calculation flow. Finally, the presented algorithm is realized and applied to evaluate university art course teaching evaluation and the realization results indicate that the presented algorithm has better performance in evaluation speed and accuracy and the algorithm can be used for system evaluation practically.

Key words: Self-organizing feature map algorithm, K-means algorithm, neural network, arts course teaching evaluation

INTRODUCTION

Teuvo Kohonen professor presented Self-Organizing Feature Map (SOM) algorithm in the 1980s and the algorithm realizes recognition, compositor, clustering and other calculation through simulating the self-organizing abilities of human' brain cell. Self-organizing map has the features of Vector Quantization and Topologically Consistency and is an effective way to describe the object consisted of uncompact data. Many researchers has presented various improvements for the practical applications of Self-organizing map algorithm but lots of defects, such as the whole training process still exists in the algorithm. The defects source is that Euclidean distance is the calculation base for the algorithm, so it makes lower classifying ability and the algorithm can be influenced by wild value and noise easily when processing the data of altitudinal nonlinear structure. So the research of improving Self-organizing feature map algorithm has become a hotspot for researcher related (Huang, 2015; Fu *et al*., 2014).

Following methods are wildly used in performance evaluation of Course Teaching Evaluation. (1) Analytic Hierarchy Process (AHP) effectively combines qualitative analysis with quantitative analysis, not only able to guarantee the systematicness and rationality of model but also able to let decision makers make full use of valuable experience and judgment, so as to provide powerful decision-making support for lots of regulatory decision making problems. The method has such strengths as clear structure and simple computation but due to its strong subjective judgment, the method also has shortcomings like low evaluation accuracy (Wang, 2012; Huo and Wen, 2012). (2) Multi-hierarchy comprehensive evaluation of fuzzy mathematics, its principle is to firstly evaluate various kinds of factors of the same thing, dividing into several big factors according to certain attribute; then carry out initial hierarchical comprehensive evaluation on certain big factor and carry out high hierarchical comprehensive evaluation on the result of initial hierarchical comprehensive evaluation based on that. The key of successful application lies in correctly specifying the factor set of fuzzy evaluation and reasonably form fuzzy evaluation matrix, obtaining evaluation result according to matrix calculation result. Make use of fuzzy comprehensive evaluation method can obtain the value grade of evaluated object or mutual precedence relationship; however, the method requires to establish appropriate evaluation matrix of evaluation object which will obtain different evaluation matrixes due to the in conformity of different experts, leading to the in conformity of final evaluation results (Nisha and Priti, 2013; Voskoglou, 2013). (3) Data Envelopment Analysis (DEA); starting from the perspective of relative efficiency, evaluates each decision-making unit and the indicators selected are only relied on input and output. As it doesn't rely on specific production function, it is effective for dealing with the evaluation with various kinds of input and output indicators, suitable for the analysis of benefit, scale economy and industry dynamics. But it is complicated in computational method, subject to certain limitations in application (Reka, 2009; Samar, 2013). (4) BP neural network method; BP neural network learning algorithm adopts gradient search technology so as to minimize the error mean square value between actual output value and desired output value; the method is adept in the processing of uncertain information. If the input mode is close to training sample, the evaluation system is able to provide correct reasoning conclusion. The method has such advantages as wide applicability and high evaluation accuracy but it also has some disadvantages like easy to fall into local minimum in the computation, low rate of convergence and etc (Li, 2013a,b).

BP neural network evaluation algorithm are wildly used in performance evaluation of complex system for their own advantages but they also have their own disadvantages in practice, such as like easy to fall into local minimum in the computation, low rate of convergence. The study redesigns a new self-organizing feature maps algorithm to overcome their own questions and bring their superiorities into full play. In doing so a new algorithm for evaluating complex system is advanced.

ANALYSIS AND ESTABLISHMENT OF EVALUATION INDICATOR SYSTEM

When we designs a new indicator system of arts course teaching evaluation, First, the study takes the arts course teaching evaluation as features. The purpose of university teaching is training senior professional talents, transferring advanced knowledge to students. As a teaching activity, art course teaching not only has the common features of university teaching and should follow to common teaching rules but also has its unique characteristics of art teaching purpose and its methods and process (Li, 2013a; Samar, 2013). So, the paper refers to experts' opinions and literatures related art course teaching first and based on relevant principles of art course teaching, decides the scope of influence of art course teaching in university through combining goal method with area method, then designs a new evaluation indicator system with such four perspectives of art course teaching as university, students ,teachers and effects. The designed indicator system has 4 first-grade indicators in it and there are twelve second-grade indicators, thirty-five third-grade indicators, the concrete contents are show in Table 1.

Table 1: Evaluation indicator system of art course teaching evaluation

Target hierarchy	First-grade indicator	Second-grade indicator	Third-grade indicator
Evaluation on art course teaching	Universities	Implementation organizing	Management implementation
			Plan implementation
			Evaluation implementation
		System construction	Management system
			Plan making
			Evaluation system
		Personnel and funds input	Construction of teachers
			Management team
			Construction of teaching materials
		Teaching concept	Emphasis put on art teaching
		Construction of art base	Base construction planning
			Base construction
		Art culture atmosphere of university	Art atmosphere
			Academic atmosphere
	Teachers	Art teaching concept	Course system of art teaching
			Art teaching motivation
			Off-campus art teaching
			Course contents of art teaching
		Art teaching ability	Art guiding ability
			Teacher-student ratio of art teaching
			Practical art ability
			Theoretical art ability
	Students	Art teaching learning	Learning effect
			Learning method
			Learning motivation
		Receptivity of art teaching	Self-learning ability
			Enrollment quality of students
			Practical ability
	Teaching effects	School art teaching effects	Practical results of university art teaching
			Theoretical results of university art teaching
			Increasing of students' art ability
			Awards of art competition
			Participation enthusiasm of off- campus
			Scientific activities
			Creative skill
			Professional skill
			Work motivation

MATERIALS AND METHODS

Designing algorithm structure for SOM algorithm: Self-Organizing Feature Map algorithm, a nervous network's outer input receiving model, divides the nervous network into different regions and the regions have different corresponding features to the input model and the input process of different nervous is finished automatically. The connecting weight of each neurons in the network has a certain distribution and they excite mutually between the nearest neurons and they inhibit mutually among the distant neurons and the more distant, the weaker inter-inhibition effect among neurons. To conclude, Self-Organizing Feature Map algorithm is a teacher-free calculation model. Compared with the traditional neural network algorithm, the former calculation centers of

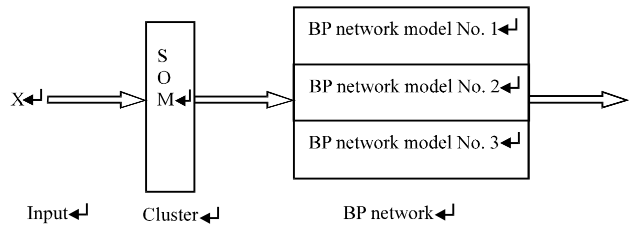

Fig. 1: Competitive network topology of new algorithm

SOM algorithm can be mapped on a plane or contour and its topological structure is maintained originally. Competitive study of SOM means that the neurons at the same level compete mutually and the winner neurons has right to modify its connecting weights close to them. During the study process, competitive study is a kind of training with no any supervision, only requires some studying samples to provide for the network instead of the ideal output. The SOM algorithm fulfill its self-organization process depending on the input samples and dividing the samples into corresponding algorithm categories. Because of absence of the ideal output samples, the supervised Self-organizing feature map algorithm is presented. The paper redesign a new calculation structure for SOM algorithm, as shown in Fig. 1 (Gao, 2011).

The Self-Organizing Feature Map algorithm is a competitive network and it is consisted of two levels, that are competition level and input level respectively. The competition level of SOM is used to classify the input samples while the input level of SOM (the competitive study network) is used for receiving the input samples. The neurons in competition level and input level are totally interconnected each other, that means that each neuron in any level is connected with all the neurons in other levels separately. The neurons in competition level compete mutually and the activities of several or only one neuron will adapt to the current input samples eventually. In the competition the winning neurons represent the training and calculation model of the input samples and each input and output node is connected mutually and it can use w to mean the connecting weight of each node, then $w_{i,j}$ means the connecting weight of the j-th node in the output level to the i-th node and X_i (i = 1, 2...N) means the calculation center of the j-th category in the input level. The training sample of model studying is composed by of N calculation indications which are the actually measured samples. Proposed that all the training samples are all in the points of the N-dimensional space and it is clearly that the samples having some similar features or in the same categories are in N-dimensional space and are relatively close to each other. The relatively close training samples will form a cluster and compose a category in N-dimensional space (Gao, 2011). The N-dimensional space will have the feature of different calculation distribution if the input training samples belong to different categories. Every calculation unit in SOM model represents a category and the calculation center is the cluster center. The distance between the training samples in the same category and the calculation center in the same category is less than the distance between the training samples and the calculation center of another category. Eyclid distance is used to calculate the distance, as shown in Eq. 1. In Eq. 1, D_j and X_i are used to mean the Euclid distance and calculation indication respectively, w_{ij} and k are used to mean the calculation center of the j-th category and t iteration times, respectively:

$$D_{j(k)} = \sum_{i=1}^{N} (x_i - w_{ij(k)})^2 \tag{1}$$

Combining SOM with K-means algorithm: The calculation combination algorithm of SOM and K-means can be called SOMK algorithm. The combination flows of SOMK algorithm can be listed as follows:

- Perform Self-organizing feature map algorithm, input the data of training samples and calculate them into SOM network and then train the SOM model to output a series of weight value. In order to reduce the training times in calculation phase and it is not necessary to completely the total converge of SOM algorithm, for example, the calculation can finish after 300 time cycle calculation in SOM training (Fu *et al*., 2014)
- Use the weight value obtained by the calculation results in the first step to initialize K-means algorithm as the initial calculation center. The combined SOMK algorithm not only can keep the advantages of self-organizing features of SOM network but also overcome the defects of original SOM algorithm, such as the bad calculation effect and long convergence time which are caused when K-means algorithm selects its initial cluster center inadequately

Improving SOMK algorithm: SOMK algorithm commonly use the representation method of vector spatial model to represent the evaluation information (the data of evaluation indicator system in this paper), that is to say, the their weight values and its feature items are used to represent the investigation data of evaluation indicators. The vector of the characteristic items can be calculated by Eq. 2 (Huang, 2015):

$$d = (W_1, W_2, ...W_m) \tag{2}$$

where, 2, d and m are used to represents corresponding weight value of the evaluation indicators and the item numbers in the evaluation indicator set. The weight values of the item t_i in the evaluation indicator d. The vector W_i (i = 1, 2...m) means the weight values of the item t_i in the evaluation indicator set d. In order to get the feature items, firstly it should delete the useless items from the evaluation's feature set and then simplify the feature items based on TF-DF rules. To avoid the situation in which an item can get a big weight value only because of its high value of a tf (tf means appearance frequency) in a specific evaluation. Equation 3 is used for obtaining the weight values:

$$Wij = (coef_{ij}) (\log N - \log df_j) \tag{3}$$

where, 3, W_{ij} is used to mean the weight of the j-th item in the i-th evaluation indicator set and $coef_{ij}$ can be calculated by e equation 4. In Eq. 4, tf_{ij} is used to mean the appearance frequency of the j-th item in the i-th evaluation indicator set:

$$coef_{ij} = \begin{Bmatrix} 1 & \text{if} & tf_{ij} = 1 \\ 1.5 & \text{if} & 1 \prec tf_{ij} \leq 5 \\ 2 & \text{if} & 5 \prec tf_{ij} \leq 10 \\ 2.5 & \text{if} & tf_{ij} \succ 10 \end{Bmatrix} \tag{4}$$

Through Eq. 5, a series of vectors which mean the evaluation set can be calculated. That is, the sets of SOMK model are classified. The distance in SOMK algorithm between the evaluation indicator vectors is the cosine distance, rather than Eyclid distance in SOM algorithm and the cosine distance can be calculated by Eq. 5:

$$d\ (doc_i, doc_j) = 1\text{-}sim\ (doc_i, doc_j) \tag{5}$$

where, sim (doc_i, doc_j) can be obtained by Eq. 6 and sim (doc_i, doc_j) in equation is called as cosine similar function. Generally speaking, the larger of sim (doc_i, doc_j) value, the more similar of the evaluation indicator i and j. Therefore, the smaller the cosine distance between these two evaluation, the less similar of the evaluation indicator:

$$sim(doc_i, doc_j) = \frac{\sum_{k=1}^{m}(w_{ik} \cdot w_{jk})}{\sqrt{\sum_{k=1}^{m}(w_{ik})^2 \cdot \sum_{k=1}^{m}(w_{jk})^2}} \tag{6}$$

Designing the calculation flow for SOMK algorithm: Based on above design, the main calculation flow to evaluation complex system by using the presented SOMK algorithm is redesigned as follows:

- The data of evaluation indicator set is represented by commonly used vector spatial model, the conventional method is used to delete the useless item in evaluation indicator set and TF-DF rules is uses to simplify the feature items to get the evaluation indicator's feature set
- Express the evaluation indicator set in the form of vectors and calculate the weight values of different feature items
- Input the vectors set of the evaluation indicator for SOM algorithm training and decide the evaluation clusters by SOM, here the number input nodes in SOM network is equal to the dimension of the evaluation vectors (gotten by evaluation indicator system) and the number of output nodes in SOM network is equals to the number of the evaluations' categories (gotten by evaluation indicator system), the it can obtain a series of output weight value
- Use the series of output weight value calculated in the step three to initialize cluster centers of K-means algorithm and use K-means algorithm to evaluate the art course teaching performance

RESULTS AND DISCUSSION

Experimental data come from the investigation results of Nanchang University (Referred to as NU) and Jiangxi Normal University (Referred to as JNU) and Jiangxi Science and Technology Normal University (Referred to as JSTNU). The paper selects relevant data of 300 students and art teachers of each university respectively as the basis for algorithm training and experimental evaluation, totally 900 art teachers' and students' data as training samples that come from visit and practical investigation of different students and art teachers. In order to guarantee the representatives of the selected art teachers and students' data, 300 students (100 from each

Table 2: Evaluation results of first grade indicators of different universities

Parameters	NU	JNU	JSTNU
Universities	3.883	4.331	3.998
Students	4.330	4.341	3.498
Teaching effects	4.006	4.652	4.298
Teachers	4.023	4.572	4.207
Final evaluation	4.101	4.467	4.076

Table 3: Part evaluation results of second grade indicators

Parameters	NU	JNU	JSTNU
Implementation organizing	3.980	3.763	4.001
System construction	3.882	3.843	3.821
Personnel and funds and input	4.091	4.557	3.871
Teaching concept	3.751	4.672	4.202
Construction of art base	4.032	4.346	4.169
Art culture atmosphere of university	3.412	4.651	4.076

Table 4: Evaluation performance comparison of different algorithms

Algorithms	Ordinary BP neural network algorithm	Comprehensive fuzzy algorithm	Algorithm in the paper
Accuracy	90.12%	80.12%	95.74%
Time consuming (S)	547	12	13

university) with more than 2 years art learning experience, 300 students with 1 years art learning experience, 300 students with less than 1 years but more than half years art learning experience. Limited to paper space, the intermediate evaluation results is omitted here, here only providing final comprehensive evaluation results and the evaluation results of first and part second grade indicators (Table 2) and taking the first grade indicator of university for example, evaluation results of second grade indicators can seen in Table 3.

In order to illustrate feasibility and practicability of the improved algorithm and original BP neural network algorithm (Li, 2013b) and comprehensive fuzzy algorithm (Nisha and Priti, 2013) are realized in the same calculation platform in the paper. The calculation platform: Windows 8, ThinkPad, Intel i5-3320 M, 2.6 GHz, DDR3 1600, 4 GB DDR3. The realization of different algorithms is shown in Table 2. The experimental results of different algorithms are indicated in Table 4 in order to calculate the experimental accuracy of different algorithms, the experimental results of evaluation effects of different teacher and students are chosen and compared with artificial evaluation results.

CONCLUSION

Both in practice and theory, course evaluation is one of the hot topics of important exploration in university management of every university at present. And the current university course evaluation algorithms and evaluation indicator systems wildly used have some defects and can not catch up with the specific demand of university course evaluation. Therefore, the research related should be focus on, especially for evaluation algorithm research for university art course evaluation. The study redesigns an efficient art course evaluation indicator system from 4 perspectives of teachers, schools, teaching effects and students and presents a evaluation algorithm based on self-organizing feature map algorithm. The experimental results indicate that the SOMK algorithm presented in the paper has favorable evaluation accuracy and practicability. The paper thinks that the next research focus is to ensure the intelligence of evaluation process and decrease the interference of artificial evaluation results.

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