Construction and analysis of vocal music evaluation system based on BP-RBF-SVM integrated neural network

Nan Jiang
Shandong Management University, 250357, Jinan, China

Corresponding author and e-mail: Nan Jiang, 14438120180222@sdmu.edu.cn

Abstract. With the development of neural network technology, integrated neural networks with better performance and stronger generalization capabilities have emerged. In order to solve the current deficiencies in the process of vocal music teaching quality evaluation in normal colleges and universities, a vocal music teaching evaluation system is proposed based on integrated neural network. The system first collects teaching evaluation data of vocal music students in normal universities. The analytic hierarchy process is used to retain important evaluation indicators, and some pre-processing of the data is used to construct evaluation learning samples; then the BP-RBF-SVM integrated neural network is used to evaluate the quality of vocal music teaching, and the evaluation results of vocal music teaching quality are obtained; finally for verification. The reliability of the model is compared with the evaluation results of a separate RBF neural network and BP neural network. The results show that the vocal music teaching quality evaluation of the integrated neural network system has a good fit and small error, which provides a new reference for the evaluation of vocal music professional teaching quality.

1. Introduction
After years of development, artificial intelligence has derived a series of interdisciplinary subjects, of which artificial neural network is an important branch. At present, with the deepening of modern deep learning and machine learning research, the development of various neural networks has reached a peak. For some complex research, a single neural network model can no longer meet the needs of today's research. The emergence of integrated neural networks solves this problem very well. In the study of Li Pengfei et al. using integrated neural networks to predict apple output in Shanxi Province, they pointed out that when a single prediction model is used to predict output, it's only based on part of the characteristics of the data, and fails to tap the potential laws of the data, and there is a large forecast deviation. The average relative error of the prediction model using the integrated neural network is within 2.5%, which is more accurate than the single prediction model [1]. In the face recognition system, the integrated neural network also played an excellent role. Chen Jia designed a facial expression recognition system based on CNN integrated learning, which trained the information in two stages. First, train three sub-networks in the first stage, and use the Batch Normalization method and the Dropout layer to accelerate the convergence of the network. Then remove the output layers of the three sub-networks and use SVM for the second stage of training to complete the prediction of the final expression. The accuracy of the final model reached 70.84% [2]. It is precisely because of the good effect of integrated neural network in data mining and information processing that
it is also used in digital predistortion processing, data mining combined with multiple sensors, and teaching evaluation [3-5].

Therefore, this article will adopt the integrated network method for the construction of the vocal music teaching evaluation system. In view of the fact that my country's higher education has entered the stage of popular education, traditional teaching models and traditional evaluation systems have become a problem of reform. Only a reasonable assessment of the teaching effect of a teacher or a course can help teachers to carry out teaching reforms and the school’s overall teaching planning. Therefore, it is not only of important theoretical significance for the construction of the teaching evaluation system of colleges and universities, but also has high practical application value.

2. Principles and algorithms

Neural network is an important technical point of artificial intelligence technology and has a relatively strong fitting ability. In view of the randomness and irregularity of the construction of college vocal music professional evaluation system, a single system cannot accurately describe the complete change characteristics of college vocal music teaching quality evaluation. Therefore, this paper integrates generalized RBF neural network, BP neural network, SVM and AHP algorithm, using their advantages to overcome their own shortcomings, and cooperate with certain procedures to realize the construction and analysis of the evaluation system of college vocal music majors.

2.1. Generalized RBF network

RBF is a scalar function that is symmetric along the radius. Its value depends only on the real-valued function of the distance from the origin, that is \( \phi(x) = \phi(||x||) \), or the distance to any point \( c \). The point \( c \) is called the center point, which is \( \phi(x,c) = \phi(||x-c||) \). Any function that satisfies \( \phi(x) = \phi(||x||) \) can be called a radial basis function, and the distance generally uses Euclidean distance. The most commonly used radial basis function is the Gaussian kernel function, in the form:

\[
k(||x-x_c||) = \exp\left\{-\frac{||x-x_c||^2}{(2\sigma^2)}\right\}
\]

Among them, \( x_c \) is the center of the kernel function, and \( \sigma \) is the width parameter of the function, which controls the radial range of the function. The structure of \( x \) radial basis function neural network can get the output of the network as:

\[
Y_j = \sum_{i=1}^{k} \omega_i \exp\left\{-\frac{||x-x_c||^2}{(2\sigma^2)}\right\}, j=1,2,...,n
\]

Similarly, the loss function of least squares is used to express:

\[
\sigma = \frac{1}{P} \sum_{j=1}^{m} \|d_j - y_jc_i\|^2
\]

RBF networks have many uses, including function approximation, time series forecasting, classification, and system control.

The generalized RBF network is a single hidden layer feedforward neural network, which includes an input layer, a hidden layer, and an output layer. The function of the hidden layer is to infer the vector from the input of low latitude to the high latitude, so that the linearity of low latitude is inseparable to the high latitude will become linearly separable, which is mainly the same as the idea of the kernel function of SVM. Using the radial basis function as the activation function of the hidden layer neuron, the transformation from the input space to the hidden layer space is nonlinear, and the transformation from the hidden layer space to the output layer space is linear. The schematic diagram is as follows.
2.2. BP neural network
The BP neural network is trained in a supervised learning method. When a pair of learning modes is provided to the network, the activation value of its neurons will propagate from the input layer to the output layer through the hidden layers, and the output of each neuron in the output layer corresponds to Network response for input mode. Then, according to the principle of reducing the error between the desired output and the actual output, the connection weights are corrected layer by layer from the output layer, through the hidden layers, and finally back to the input layer. The schematic diagram is as follows.

2.3. SVM support vector machine
The support vector machine itself is a classifier. Suppose there are some data points in the two-dimensional plane, they belong to two different categories, we try to separate them. If you can draw a straight line in this plane to separate the two types of points, these data points are called linearly separable, as shown in Figure 3. This dividing line is also called the "hyperplane", and the three points on the extreme edge are also called support points. If these data points are in n-dimensional space, the dividing hyperplane is obviously n-1 dimensional, then the edge The three points above are called vectors, and the equation of this hyperplane can be expressed as: W1*X+b=0, where W is the weight; b is the bias term.
Figure 3. Schematic diagram of linear classification in two-dimensional space.

However, in most cases, the data is non-linear and it is difficult to get the segmentation line. Therefore, we need to use kernel function to solve the problem, mainly using the following three categories:

- **Linear kernel:** $K(x, xi) = x \ast xi$
- **RBF:** $K(x, xi) = \exp\left(-\frac{(x-xi)^2}{\delta^2}\right)$
- **Poly:** $K(x, xi) = ((x \ast xi) + 1)^d$
- **Sigmoid:** $K(x, xi) = \tanh(\eta < x, xi > + \theta)$

Their main function is to map the linearly indivisible data in the space to a high-dimensional feature space, so that the data in the feature space is separable, and the inner product of the feature space can be performed only in the input space.

### 2.4. AHP analytic hierarchy process

AHP is often used to construct an evaluation system. When using AHP to solve complex problems, it needs to be layered in the following ways. The target layer represents the overall goal to be achieved by the problem, and each element of the measure layer represents the specific methods that need to be taken to achieve the final goal, starting from the criteria. The link between the above and the next is, for the target level, a measure to solve the final problem, but it is not specific and implementable. For the measure level, it is a goal to be achieved by specific measures. The Analytic Hierarchy Process has no hard and fast rules on the number of layers. When it is used, the target problem can be decomposed layer by layer, until finally a specific and implementable measure to solve the problem is found. So it is very practical to deal with the complicated problem of teaching evaluation. Another reason why this paper uses AHP to deal with evaluation indicators is that the algorithm is a combination of qualitative and quantitative analysis methods.

In teaching evaluation, each evaluation index is the generalization ability of the neural network of teaching activities, which will be affected by the complexity of the network structure to a large extent. The size of the network structure, the number of hidden layers and the number of hidden layer nodes will directly affect the performance of the network. The generalization ability of the network model will be enhanced with the simplification of the network structure. In actual operation, the network structure can be optimized by reducing the dimensionality of the input data (that is, reducing the number of neurons in the input layer of the neural network) and the number of nodes in the hidden layer of neurons. The evaluation indicators can be screened by AHP, as shown in Figure 4. Therefore, the flow chart of the integrated neural network combined with AHP in the vocal music teaching evaluation system is shown in Figure 5. The input of BP neural network and RBF neural network is reduced, in order to achieve the goal of network structure optimization. Then the evaluation results of
the two are used as the input of the support vector machine, and the weight of the evaluation results of the two networks is determined by the support vector machine. Finally, the evaluation results of college vocal music teaching are obtained according to the weights.

Figure 4. Flow chart of screening indicators.
3. Experimental results and discussion

3.1. Experimental design
Vocal music is a highly practical subject. The evaluation of its teaching quality must first focus on practicality, reflecting the students' self-learning ability and comprehensive quality. Secondly, we must pay attention to the principle of objectivity, seek truth from facts, and examine and evaluate all aspects of vocal music teaching from multiple perspectives; secondly, we must take into account the impact of the school environment. A good environment can allow vocal students to practice and train. In the end, we must continue to motivate students and teachers. The construction of a vocal music teaching evaluation system can improve the quality of teaching and stimulate teachers’ enthusiasm for teaching and students’ motivation and enthusiasm for learning. Based on references [6-10], this paper constructs a set of vocal music teaching evaluation system involving work attitude, business level, hardware environment and teaching effect. The detailed indicators are shown in Table 1.
Table 1. Evaluation index system of vocal music teaching quality.

| Target layer | Criterion layer | Measures layer |
|--------------|-----------------|----------------|
|              | Work attitude B1| C1 Actively respond to students' learning needs |
|              |                 | C2 Sufficient lesson preparation, serious devotion to teaching |
|              |                 | C3 Homework correction; answer questions |
|              | Teaching ability B2 | C4 Pay attention to the all-round development of students and be able to provide personalized guidance |
|              |                 | C5 Familiar with vocal music courses, with clear teaching ideas |
|              |                 | C6 Proficiency in the application of modern teaching methods |
|              |                 | C7 Class is not boring, students are interested |
|              |                 | C8 Flexible teaching methods, suitable for the characteristics of vocal music majors |
|              |                 | C9 Have your own unique understanding, effective use case explanation |
|              |                 | C10 Good at controlling the atmosphere and rhythm of the classroom |
|              | Hardware environment B3 | C11 Teaching Documents: Vocal Music Professional Training Plan and Teaching Syllabus are reasonable and standardized |
|              |                 | C12 Teaching venue: complete basic equipment and quiet environment |
|              |                 | C13 Teaching staff: whether academic qualifications and majors correspond to each other |
|              | Teaching effect B4 | C14 Strong knowledge and gain in learning |
|              |                 | C15 You want to listen to this teacher again |

Collected 300 teaching evaluation data of vocal music major of a music college of a normal university, and carried out matlab training experiment. The format of the data is shown in Table 2. In the table, x1, x2, ..., x15 represent a student’s corresponding index of the teacher’s class The scores scored, y represents the evaluation results of teachers and vocal music teaching. Here, the first 200 data are selected as training data, and the last 100 data are used as test data, and the final effective model expected to be obtained is verified through experiments.
Table 2. Experimental data.

| Number | x1  | x2  | x3  | x4  | ...... | x14 | x15 | y   |
|--------|-----|-----|-----|-----|--------|-----|-----|-----|
| 1      | 78  | 93  | 72  | 93  | ...... | 86  | 84  | 82  |
| 2      | 93  | 75  | 92  | 86  | ...... | 75  | 93  | 84  |
| 3      | 91  | 94  | 76  | 98  | ...... | 92  | 83  | 90  |
| 4      | 92  | 72  | 92  | 73  | ...... | 71  | 75  | 77  |
| 5      | 93  | 77  | 76  | 85  | ...... | 88  | 85  | 84  |
| 6      | 87  | 87  | 92  | 91  | ...... | 81  | 85  | 83  |
| 7      | 91  | 82  | 85  | 95  | ...... | 86  | 81  | 87  |
| 8      | 86  | 83  | 86  | 88  | ...... | 98  | 93  | 87  |
| 9      | 95  | 94  | 87  | 86  | ...... | 72  | 79  | 85  |
| ......  | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 300    | 74  | 76  | 79  | 83  | ...... | 87  | 86  | 83  |

4. Results and discussion

Using the method of screening indicators in Figure 4 to study the evaluation index system of vocal music teaching quality, it is shown that the relatively important indicators are C2 sufficient lesson preparation and serious devotion in teaching; C4 focuses on the overall development of students and can provide personalized guidance; C8 has flexible teaching methods, suitable for the characteristics of vocal music profession; C9 has its own unique understanding and effective use case explanation; C12 teaching site: perfect basic equipment, quiet environment; C14 has strong knowledge and learned something; C15 you want to listen to this teacher again lecture. The evaluation results of the training model after normalization of the above data using the maximum method are shown in the following figure. The scores are numbered in ascending order. The first 200 are the test set of the integrated neural network, and the last 100 are the evaluation and estimation results. The results show that the fitting effect is better.

Figure 6. Comparison of vocal music teaching evaluation.
In order to illustrate the effect of vocal music teaching evaluation of integrated neural network, it was compared with BP neural network and RBF combined with AHP, and the test results of one hundred data were selected, as shown in Figure 7 and Table 3. Compared with BP and RBF, the integrated neural network has a better evaluation effect on the evaluation indicators RMSE and MAE, and the predicted value has a smaller evaluation error and higher evaluation accuracy.

![Figure 7. Comparison of vocal music teaching quality evaluation.](image)

**Table 3. Comparison results of vocal music teaching quality.**

| Method             | RMSE   | MAE   |
|--------------------|--------|-------|
| Integrated neural network | 0.3152 | 0.1834 |
| BP                 | 0.3841 | 0.2433 |
| RBF                | 0.8236 | 0.6231 |

**5. Conclusions**

In order to improve the quality of vocal music teaching, stimulate teachers’ enthusiasm for teaching and students’ motivation and enthusiasm for learning, this article establishes a set of vocal music teaching quality evaluation system from five aspects: working attitude, professional level, hardware environment and teaching effect, and proposes a system based on integration. Compared with BP and RBF, it is found that the integrated neural network can effectively improve the effect of vocal music professional teaching quality evaluation, and provide a new reference for vocal music professional teaching quality evaluation. Although this model has certain effects, there may be insufficient comprehensive shortcomings in the evaluation of vocal music professional teaching quality, which affects the adaptability of the model. The follow-up will study the influence of more evaluation indicators on the results of teaching quality evaluation to improve the applicability and coverage of the model.
References

[1] Li Pengfei, Wang Qingqing, Wu Jianhong, Chen Huaxue. Integrated forecasting research based on BP neural network, ARIMA and LS-SVM model——Empirical research on apple production in Shaanxi Province from 1978 to 2017[J]. Jiangsu Agricultural Sciences, 2020, 48(04):294-300.

[2] Chen Jia, Chu Lili, Zhou Ying. Design of facial expression recognition system based on CNN integrated learning [J]. Computer and Information Technology, 2021, 29(01): 10-12.

[3] Jung Sunghoon; Kim Yeonghwan; Woo Youngyun; Lee Chungyong. A two-step approach for DLA-based digital predistortion using an integrated neural network [J] Signal Processing Volume 177, 2020.

[4] Chang Fangle; Heinemann Paul H. Prediction of human odour assessments based on hedonic tone method using instrument measurements and multi-sensor data fusion integrated neural networks [J]Biosystems Engineering Volume 200, 2020. PP 272-283

[5] Wang Lei, Zhang Huijuan. Research on College Teaching Quality Evaluation System Integrated Neural Network [J]. Modern Electronic Technology, 2021, 44(03): 69-73.

[6] Zhang Yi. Research on the Evaluation Standard System of Vocal Music Teaching in Normal Universities [J]. People's Forum, 2015(33):163-164.

[7] Zhang Xiaona. An analysis of the employment status of college art graduates—taking vocal music graduates as an example [J]. Art Criticism, 2019(02):162-164.

[8] Yuan Jian. Research on singing evaluation model based on RBF radial basis network [J]. Computer and Digital Engineering, 2017, 45(06): 1101-1104.

[9] Zhao Shun. Research on the evaluation of art teaching based on the salvia algorithm to optimize the neural network [J]. Microcomputer Applications, 2020, 36(09): 139-142.

[10] Guo Xing. Research and application of teaching evaluation model optimization method [D]. Northeastern University, 2015.