(IJACSA) International Journal of Advanced Computer Science and Applications,
Vol. 14, No. 6, 2023

The Application of Intelligent Evaluation Method with Deep Learning in Calligraphy Teaching

Yu Wang
School of Humanities, Weinan Normal University, Weinan, 714099, China

***Abstract*—Scientific and effective teaching quality evaluation (QE) is helpful to improve teaching mode and improve teaching quality. At present, calligraphy teaching (CT) QE methods are few in number and have poor evaluation effect. Aiming at these problems, deep learning (DL) is introduced to realize intelligent evaluation of CT quality. First, based on relevant research, the CTQE indicator system is constructed. Secondly, rough set and the principal component analysis (PCA) are used to reduce the dimension of the CTQE index system and extract four common factors. Then, the corresponding index data is input into the BP neural network (BPNN) model optimized by the improved sparrow search algorithm for fitting. Finally, combining the above contents, the improved sparrow search algorithm (ISSA) BPNN model is built to realize the intelligent evaluation of CT quality. The experimental results show that the loss value of ISSA-BPN model is 0.21, and the fitting degree of CT data is 0.953. The evaluation Accuracy is 95%, Precision is 0.945, Recall is 0.923, F1 is 0.942, and AUC is 0.967. These values are superior to the most advanced teaching QE model available. The SSA-BPNNCTQE model proposed in the study has excellent performance in CTQE. This is of positive significance to the improvement of teaching quality and students' calligraphy level.**

Keywords—Deep learning; calligraphy teaching; BPNN; intelligent evaluation; sparrow search algorithm

I. INTRODUCTION

In recent years, China has paid more and more attention to the inheritance and development of traditional culture. Chinese calligraphy has been handed down for a long time and is an important part of Chinese traditional culture [1]. In addition, calligraphy is also an art form that can fully display the meaning and beauty of Chinese characters, and can give people a beautiful feeling. In China, calligraphy is also known as wordless poetry and pictureless painting. It is an important way to cultivate sentiment, cultivate character and enhance aesthetic taste. Therefore, CT has received extensive attention in China, and relevant courses have been offered at different stages [2,3]. In this context, CTQE has also become a hot research topic. It provides theoretical support and implementation approaches for the improvement of CT mode and the improvement of students' calligraphy performance. At present, the main evaluation method of CTQE is based on expert opinions and student feedback, which has problems such as extremely low efficiency and objective evaluation results. Therefore, the problem of research is to find suitable CTQE methods to improve the efficiency and objectivity of CTQE. The reason for these problems is not only the ideal selection method, but also the unique characteristics of calligraphy Chinese characters, such as a large number of Chinese characters and similar characters. The large number of Chinese characters makes the traditional CTQE method very effective, but due to the development of technology, the CTQE method has not been improved in a timely manner. Scientific and effective CTQE can promote the improvement of calligraphy teaching mode and improve the quality of calligraphy teaching. Therefore, research needs to design effective CTQE methods. DL is one of the important technologies to realize industry intelligence and automation, and has achieved remarkable results in data mining, machine learning, artificial intelligence and other fields [4,5]. Therefore, DL is introduced to realize the intelligent evaluation of CT quality, so as to help calligraphy teachers understand the defects in the teaching process more intuitively. Thus, the teaching quality and students' calligraphy level have been improved, which has positive significance for the inheritance and promotion of Chinese calligraphy culture.

The key components of the study include the construction of a CTQE indicator system, PCA based common factor extraction, improved BPNN based CTQE model, ISSA-BPNNCT quality intelligent evaluation model, and research results. The main research results are the comparison results between the ISSA-BPNN model and other models under different model evaluation values. There are two main innovations in the research. The first point is to use the improved sparrow search algorithm (ISSA) to optimize the BP neural network (BPNN), so as to build ISSA-BPNN and improve the performance of the model. The second point is to use ISSA-BPNN to realize intelligent evaluation of CT quality to improve the efficiency and objectivity of CT evaluation. Scientific and effective CTQE can help improve the quality of calligraphy teaching and also improve the efficiency of students' learning calligraphy. In order to find a suitable CTQE method, an improved sparrow search algorithm was introduced based on the BPNN algorithm.

II. RELATED WORKS

China's traditional culture has a long history of inheritance and profound heritage, and is loved and yearned for by people all over the world. Calligraphy is an important part of China's traditional culture, which contains rich artistic aesthetic value. CT is an important course to carry forward our traditional culture, which can improve students' aesthetic taste, cultivate students' sentiment, and cultivate students' artistic aesthetics. Therefore, it has attracted the attention of many scholars. Fang et al. conducted a comprehensive discussion and analysis on the curriculum of calligraphy in Chinese universities. And they have studied the improvement and perfection of calligraphy curriculum, providing theoretical support for the reform of calligraphy curriculum in China [6]. Under the background of journalism, Liu and others conducted a questionnaire survey on students and teachers of calligraphy in colleges and universities. Thus, the effect of CT reform is analyzed, and the reform strategy is given according to the results of the questionnaire [7]. Huda et al. analyzed the effect of students' calligraphy learning based on Bloom's revised classification to improve CT quality [8]. Sun takes Anhui University of Finance and Economics as an example to explore the auxiliary role of calligraphy learning in the training of environmental design talents. It provides ideas for the development of environmental design industry [9]. Liu discussed the frequency of calligraphic elements in classic films released in China in recent years, and the effects in films. It provides ideas for the inheritance and promotion of Chinese calligraphy aesthetics [10]. Huda S proposed a calligraphy learning assistant system based on projection mapping to improve students' calligraphy learning efficiency and improve their calligraphy level [11]. Kobayashi et al. based on DL, combined with image and human motion, then proposed a calligraphy generation method to realize automatic calligraphy writing [12]. Based on aesthetic psychology, Jin and others combined calligraphy and painting elements with cultural and creative products. It has achieved innovation in the design of cultural and creative products and contributed to the inheritance of calligraphy and painting culture [13].

Xi et al. evaluated the sorting capacity of urban domestic waste in China in combination with analytic hierarchy process (AHP) and BPNN to help cities improve their waste treatment level [14]. Liao et al. used genetic algorithm (GA) to optimize BPNN. Thus, the viscosity model of aluminum alloy is established, which provides a new method for the production and optimization of aluminum alloy [15]. Wen et al. combined random forest (RF) and particle swarm optimization (PSO) to optimize BPNN. Based on the optimized BPNN, the carbon dioxide emissions of China's commercial sector are predicted. It provides data support for China's environmental protection [16]. Chang et al. proposed a back-propagation neural network optimized by thought evolution algorithm to realize the prediction of the penetration quality of asymmetric fillet weld [17]. Li et al. used Levenberg-Marquardt algorithm to optimize BP neural network, and thus proposed a new approximate response model of quadrant detector. The model has good application prospects in beam position measurement [18]. Song et al. conducted mathematical modeling of solid oxide fuel cell (SOFC) through BPNN to evaluate and predict the performance of SOFC at different furnace temperatures. The error of the prediction method is less than 5%, and it is better than the traditional method [19]. In order to make up for the defects of BPNN, Han et al. selected Genetic Algorithm (GA) to obtain network parameters, optimize BPNN, and evaluate the effect of UAV shape product design scheme based on optimized BPNN. The relative error of this evaluation method is less than 4%, and it can evaluate the design scheme quickly and scientifically [20]. Li and others believe that the current motion management system has many defects, such as low accuracy of output results and poor efficiency. To solve these problems, they proposed an optimization method based on BPNN to optimize the motion management system. The effect of this optimization method is ideal and can significantly improve the performance of the system [21].

In summary, CT accounts for a significant proportion in China's education system, while BPNN is also relatively mature and widely used in various fields. However, there is currently limited research on the combination of BPNN and CT, and the current CTQE method has significant shortcomings. Therefore, this study proposes an improved BPNN and utilizes it to achieve intelligent evaluation of CT, improving the accuracy and objectivity of CTQE. By introducing an improved BPNN into CT, the research has to some extent enriched the research results in this field and also made up for the shortcomings of weak objectivity in current CTQE methods. Therefore, it can provide data and theoretical support for CT reform.

III. DL-BASED CTQE METHOD

A. Construction and Reduction of CTQE System

In CT, teaching QE can help teachers to more intuitively understand the problems in the teaching process, so as to urge teachers to take measures to improve the teaching mode and improve the teaching quality. Therefore, it is very necessary to evaluate the quality of CT. To conduct CTQE, first of all, we should select indicators and build a CTQE indicator system. Combined with the previous research results and the current situation of CT in China, the study evaluated the teaching quality from five dimensions. It includes CT content, teaching methods, teaching environment, teaching process and teaching effect. The research and construction of the CTQE indicator system is shown in Table I.

TABLE I. EVALUATION INDEX SYSTEM OF CALLIGRAPHY TEACHING QUALITY

First-Level Indicators	Code	Secondary Indicators	Code
Content of courses	X_1	Professors' etymology	Y_1
		Professor's font	Y_2
		Calligraphy knowledge	Y_3
		Calligraphy skills	Y_4
		Cultural knowledge	Y_5
		Related activities	Y_6
Teaching method	X_2	Teaching language	Y_7
		Auxiliary teaching	Y_8
Teaching environment	X_3	Classroom layout	Y_9
		Background music	Y_{10}
Teaching process	X_4	Classroom power	Y_{11}
		Teacher role	Y_{12}
		Student role	Y_{13}
		Control of learning process	Y_{14}
		Teacher's calligraphy ability	Y_{15}
Teaching effectiveness	X_5	Learner satisfaction	Y_{16}
		Learner self-assessment	Y_{17}
		Other comments of learners	Y_{18}

CT content should be mainly from two aspects, namely, the teaching of calligraphy knowledge and calligraphy skills. To this end, in this dimension, the study includes the teaching of character sources, fonts, calligraphy knowledge, calligraphy skills, cultural knowledge, and related activities. In the dimension of teaching methods, the study includes two indicators that can evaluate teaching innovation: teaching language and auxiliary teaching methods. In the dimension of teaching environment, the study selected two indicators: classroom layout and classroom background music. In the dimension of teaching process, the study selected five indicators. They include teacher's classroom power, whether the teacher's role is successfully played, whether the student's role is successfully played, whether the teacher has sufficient control in the process of student learning, and the teacher's calligraphy level and ability. In the dimension of teaching effect, the study selected three dimensions: student satisfaction, student self-evaluation score and others' score on students. The weight data corresponding to each index in Table I is input into the BPNN model for fitting learning. Then the intelligent evaluation of CT quality can be realized according to the predicted output results of the BPNN model. In Table I, KMO and Bartlett test are used to test various indicators, so as to analyze the correlation between indicators. Then the effectiveness of the CTQE indicator system built in the study is verified. KMO and Bartlett test results are shown in Table II.

TABLE II. KMO AND BARTLETT TEST

Project		***P***
KMO inspection		0.638
Bartlett sphericity test	Approximate chi-square	7604.358
	DF	0.74
	Significance	0.000

In Table II, KMP test and Bartlett test of all indicators have passed, and P value is less than 0.05. It means the indicators of the CTQE indicator system built in the study have significant correlation. The validity of the CTQE index system built in the study is further verified. However, KMO test is only 0.638, which indicates that in the CTQE indicator system shown in Table I, some indicators have weak correlation. But, the CTQE indicator system shown in Table I contains a large number of indicators, some of which cannot effectively reflect the CT quality. And the calculation amount in the subsequent calculation will be increased. Therefore, the reduction of rough sets is studied. Rough set has a good effect in dealing with uncertain data, so it is often used to deal with uncertain problems. The attribute reduction function of rough set is used to deal with the CTQE indicator system shown in Table I, so as to eliminate the invalid or weak correlation indicators. The index system was simplified to improve the accuracy of teaching quality evaluation. After reduction, a simplified CTQE indicator system is obtained, as shown in Table III.

In Table III, after rough set reduction, eight redundant indicators are deleted, so that the number of indicators included in the CTQE indicator system is reduced from 18 to 10. This method can effectively improve the efficiency and accuracy of CT quality evaluation.

B. *Common Factor Extraction based on PCA*

After using rough set to reduce the CTQE index system, a simplified CTQE index system containing 10 evaluation indicators is obtained. It reduces the amount of calculation for subsequent teaching quality evaluation and improves the efficiency and accuracy of teaching quality evaluation. However, the simplified CTQE indicator system still contains a large number of indicators. If these indicator data are input into the BPNN model, 10 input layer nodes need to be constructed. This will cause the network structure of the model to be too complex, and the prediction performance of the model will also be significantly reduced. Therefore, the principal component analysis (PCA) is used to extract common factors to further reduce the dimension of indicators. First of all, the deviation standardization method is used to standardize all indicators. It can avoid the performance degradation of the model due to the inconsistency of the unit and magnitude between different indicators. The standardization process is shown in Equation (1).

$$X' = \frac{x_{ij} x_{\min}}{x_{\max} - x_{\min}} \tag{1}$$

X' is the index data value obtained after standardization; x_{ij} is the data value corresponding to the j index in the i calligraphy lesson; $x_{\max}, x_{\min}$ represent the maximum and minimum values of x_{ij} in Equation (1). The maximum variance method is used for factor analysis of the indicator system to obtain the factor contribution rate in Table IV.

In Table IV, four common factors are extracted, and the cumulative variance of these four common factors exceeds 84%. This data can show that the four common factors extracted can effectively and objectively reflect the teaching situation of calligraphy class, so as to evaluate the teaching quality of calligraphy class. The factors in Table IV are descriptive statistics, and then the factor component matrix is obtained to analyze the correlation between each index and each common factor, so as to find the index of common factor mapping. The factor component matrix is shown in Table V.

From Table V, corresponding indicators that can reflect four common factors are extracted, namely Y_4, Y_8, Y_{15} and Y_{18}. This shows the four indicators of calligraphy skill teaching, auxiliary teaching methods, teachers' calligraphy level and others' evaluation of students. It can effectively and comprehensively reflect the effect of CT. Therefore, these four indicators are selected to evaluate CT quality.

TABLE III. SIMPLIFIED EVALUATION INDEX SYSTEM OF CALLIGRAPHY TEACHING QUALITY

First-Level Indicators	**Code**	**Secondary Indicators**	**Code**
Content of courses	X_1	Calligraphy knowledge	Y_3
		Calligraphy skills	Y_4
		Cultural knowledge	Y_5
Teaching method	X_2	Auxiliary teaching	Y_8
Teaching process	X_4	Classroom power	Y_{11}
		Teacher role	Y_{12}
		Student role	Y_{13}
		Teacher's calligraphy ability	Y_{15}
Teaching effectiveness	X_5	Learner self-assessment	Y_{17}
		Other comments of learners	Y_{18}

TABLE IV. FACTOR CONTRIBUTION RATE

Composition	Initial Characteristics			Extract The Sum of the Squares of the Load		
	Total	*Percent Variance/%*	*Cumulative Contribution Rate/%*	*Total*	*Percent Variance/%*	*Cumulative Contribution Rate/%*
1	8.785	37.140	37.140	8.785	37.140	37.140
2	4.833	22.054	59.194	4.833	22.054	59.194
3	3.575	15.438	74.432	3.575	15.438	74.432
4	2.038	10.053	84.685	2.038	10.053	84.685
5	.932	3.165	87.850	.932	3.165	87.850
6	.910	3.054	90.904	.910	3.054	90.904
7	.852	2.843	93.747	.852	2.843	93.747
8	.844	2.782	96.529	.844	2.782	96.529
9	.752	2.134	98.663	.752	2.134	98.663
10	.332	1.337	100.000	.332	1.337	100.000

TABLE V. FACTOR COMPONENT MATRIX

Indicator Code	1	2	3	4
Y_3	0.083	0.032	0.167	0.073
Y_4	0.854	0.072	0.302	0.147
Y_5	0.157	0.135	0.134	0.025
Y_8	0.086	0.758	0.135	0.308
Y_{11}	0.149	0.062	0.226	0.094
Y_{12}	0.203	0.234	0.309	0.413
Y_{13}	0.342	0.130	0.184	0.078
Y_{15}	0.325	0.083	0.882	0.024
Y_{17}	0.053	0.344	0.006	0.056
Y_{18}	0.144	0.098	0.178	0.769

C. CTQE Model based on Improved BPNN

Based on the CTQE index system constructed by the research, combined with AHP and expert evaluation method, the teaching quality of calligraphy can be analyzed and evaluated. However, this CT quality evaluation method is easily affected by subjective factors, so it lacks objectivity, scientificity and effectiveness. To solve this problem, DL is introduced to realize the intelligent evaluation of CT quality, so as to eliminate the negative impact of subjective factors on the evaluation results of teaching quality. The realization way is to determine the weight of Y_4, Y_8, Y_{15} and Y_{18} by using expert scoring method combined with AHP and fuzzy comprehensive evaluation. In the experiment, the data related to these four indicators are input into the BPNN model for fitting and learning, and the prediction score is obtained. CT quality was evaluated according to the predicted score. However, the traditional BPNN has some defects, and its performance is greatly affected by the initial parameter value. Therefore, SSA is studied to obtain the optimal parameters of BPNN model, so as to improve the performance of BPNN model. The algorithm of SSA is simple to implement and has good robustness and optimization effect, but it also has the defects of poor convergence performance and weak global optimization ability. To solve this problem, research and propose strategies to optimize it. First, the sparrow population in the algorithm is initialized using the idea of reverse learning. A sparrow population $X_{i,j}$ is randomly generated, and the inverse solution $X_{i,j}^{*}$ of $X_{i,j}$ is calculated, as shown in Equation (2).

$$X_{i,j}^{*} = ub_{i,j} + lb_{i,j} - X_{i,j} \tag{2}$$

$ub_{i,j}, lb_{i,j}$ are the upper and lower limit of the j dimension of individual i in the initial sparrow population in Equation (1). The fitness value of the individual in the reverse population is calculated. If there is Equation (2), the individual is regarded as the initial population.

$$fit\left(X_{i,j}^{*}\right) < fit\left(X_{i,j}\right) \tag{3}$$

The strategy of Equation (1) and (2) can improve the population diversity of SSA, thus optimizing the global optimization ability of SSA. In SSA, the location update of the individual discoverer in the next iteration will refer to its current location information. This characteristic makes the convergence performance and search performance of SSA not ideal at the beginning of the iteration. The global search ability of SSA is poor at the end of the iteration, and it is easy to fall into local extremum. In view of this defect, a nonlinear weighting factor λ is proposed to improve the location update strategy of the individual discoverer in SSA, as shown in Equation (4).

$$\lambda = \left(t / T_{\max}\right)^{2} \tag{4}$$

t is the current iteration number; $T_{\max}$ is the maximum number of iterations in Equation (4). The strategy of Equation (5) is used to update the discoverer position.

$$X_{i,j}^{t+1} = \begin{cases} \lambda X_{i,j}^{t} & if\ R_2 < ST \\ X_{i,j}^{t} + Q & if\ R_2 \ge ST \end{cases} \tag{5}$$

$X_{i,j}^{t}$ is the position of the j dimension of individual i in the current iteration in Equation (5); Q is a normal distribution random number; R_2, ST are the early warning value and the early warning threshold. For the vigilance, the strategy of Equation (6) is used to update.

$$X_{i,j}^{t+1} = \begin{cases} X_{best}^{t} + \beta \left| X_{i,j}^{t} - X_{best}^{t} \right| & if\ f_i > f_g \\ X_{i,j}^{t} + \beta \left(X_{worst}^{t} - X_{best}^{t} \right) & if\ f_i = f_g \end{cases} \tag{6}$$

In Equation (6), $X_{worst}^{t}, X_{best}^{t}$ are the worst individual and the best individual in the current iteration; β is a normal distribution random number; f_i is the fitness value of individual i; f_g is the fitness value of the worst individual in all iterations. Using Equation (4), (5) and (6) can effectively reduce the dependence of individual location updates on their current location information, thus improving the convergence and optimization performance of SSA. ISSA is used to optimize the parameters of BPNN, and the ISSA-BPNN model is constructed. Based on the ISSA-BPNN model, the intelligent evaluation of CT quality is realized. The ISSA-BPNNCT quality intelligent evaluation model is shown in Fig. 1.

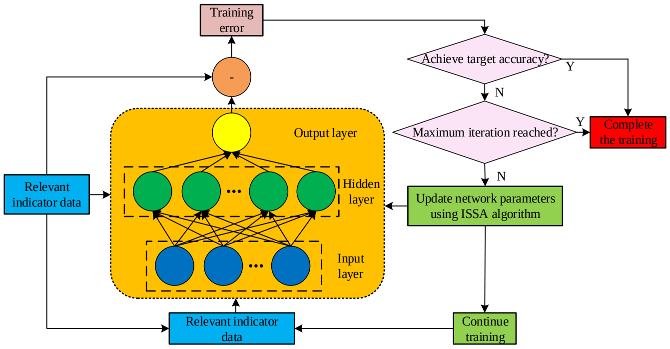
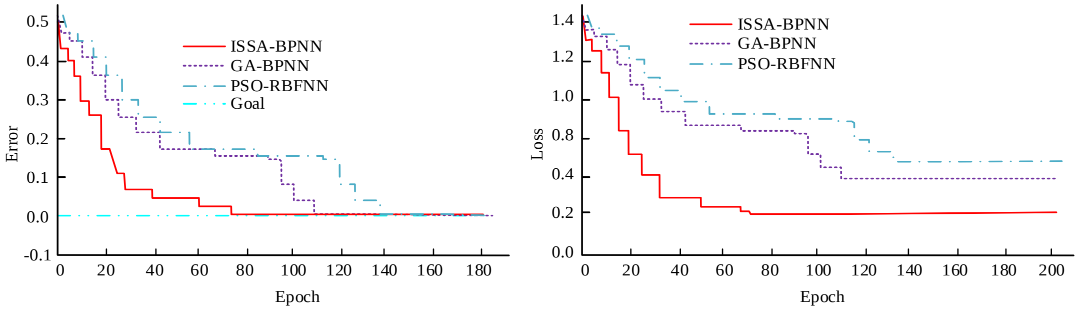


Fig. 1. ISSA-BPNN intelligent evaluation model of calligraphy teaching quality.

IV. ISSA-BPNNCT QUALITY INTELLIGENT EVALUATION MODEL

Calligraphy is an important part of China's traditional culture, which contains rich artistic aesthetic value. CT is to promote our traditional culture. It is an important course that can improve students' aesthetic taste, cultivate students' sentiment, and cultivate students' artistic aesthetics, so it has attracted the attention of many scholars. To realize the intelligent and automatic evaluation of CT quality, the intelligent evaluation model of CT quality is built based on ISSA-BPNN. Relevant data were collected in the teaching system of calligraphy major in a university, and the experimental data set was constructed to test the performance of ISSA-BPNNCT quality intelligent evaluation model. 70% of the data in the experimental data set is randomly divided to train the model, which is recorded as the training sample set, and the other 30% of the data is used to test the model. At present, the common intelligent evaluation models of teaching quality include BPNN (GA-BPNN) model optimized by GA and radial basis function neural network (PSO-RBFNN) model optimized by PSO. The ISSA-BPN model, GA-BPNN model and PSO-RBFNN model are trained by using the training sample set. During the training, the changes of the loss value and error value of the above models are shown in Fig. 2. In Fig. 2, when the minimum error and the minimum loss value are reached, the ISSA-BPN model only needs 71 iterations, 42 and 71 times less than GA-BPNN model and PSO-RBFNN model, respectively. In Fig. 2(b), the loss value of ISSA-BPN model is 0.21, which is 0.23 and 0.30 lower than GA-BPNN model and PSO-RBFNN model, respectively. In the above results, it is proved that the convergence of ISSA-BPN model is better than GA-BPNN model and PSO-RBFNN model.

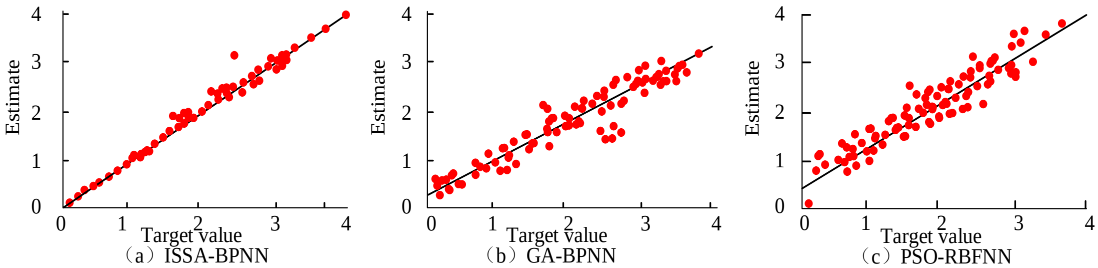
In the process of fitting the model to CT data, the fitting degree of several models and CT data is calculated and recorded in the experiment, as shown in Fig. 3. In Fig. 3(a), the fitting degree of ISSA-BPN model reaches 0.953. In Fig. 3(b), the fitting degree of GA-BPNN model reaches 0.933, 0.020 lower than ISSA-BPN model. In Fig. 3(c), the fitting degree of PSO-RBFNN model reaches 0.902, 0.051 lower than ISSA-BPN model. The ISSA-BPN model has a higher fitting degree with the data and better performance in CTQE.



(a) Error

(a) Loss

Fig. 2. Change of loss value and error value of the model.



（a）ISSA-BPNN

（b）GA-BPNN

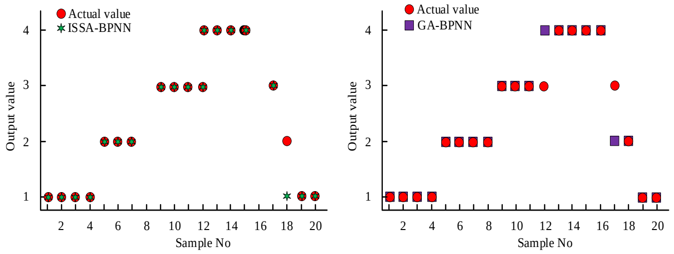
（c）PSO-RBFNN

Fig. 3. Fitting degree of model and calligraphy teaching data.

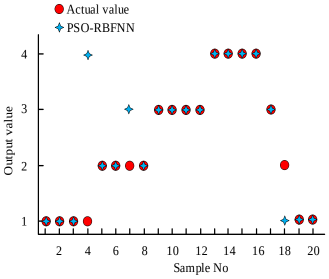
20 samples were used to analyze the accuracy of ISSA-BPN model, GA-BPNN model and PSO-RBFNN model in CTQE. In the study, according to the evaluation score, the CT quality was divided into four grades, namely 4: excellent; 3: good; 2: general; 1: poor. Among the 20 samples, the difference between the predicted output of ISSA-BPN model, GA-BPNN model and PSO-RBFNN model and the actual sample value is shown in Fig. 4. In Fig. 4(a), in the evaluation of 20 samples, the ISSA-BPN model only evaluated the value of the sample with the number of 18, which was inconsistent with the actual value. However, the evaluation value is quite close to the actual value, and the evaluation accuracy rate reaches 95%. In Fig. 4(b), in the evaluation of 20 samples by GA-BPNN model, the evaluation values of samples numbered 12 and 17 are inconsistent with the actual values. Moreover, the evaluation value of the two samples is quite close to the actual value grade, and the evaluation accuracy rate is 90%, which is 5% lower than the ISSA-BPN model. In Fig. 4(c), PSO-RBFNN model evaluated 20 samples, and the evaluation values of samples numbered 4, 7 and 18 were inconsistent with the actual values. In the evaluation of the sample numbered 4, the evaluation value differs greatly from the actual value. In the evaluation of samples numbered 7 and 18, the difference between the evaluation value and the actual value is small, and the evaluation accuracy is 85%, which is 10% lower than the ISSA-BPN model. The above results can show that the ISSA-BPN model is more accurate in the evaluation of CT quality, and even if there is an evaluation error, the evaluation error is also within the acceptable range.

The performance of ISSA-BPN, GA-BPNN and PSO-RBFNN are tested by using Precision and Recall indicators. The Precision and Recall of SSA-BPN, GA-BPNN and PSO-RBFNN are shown in Fig. 5. In Fig. 5(a), the precision value of ISSA-BPN is 0.945, 0.142 higher than GA-BPNN and 0.208 higher than PSO-RBFNN. In Fig. 5(b), the Recall value of ISSA-BPN is 0.923, 0.213 higher than GA-BPNN and 0.230 higher than PSO-RBFNN.

Fig. 6 shows the F1 value changes of ISSA-BPN, GA-BPNN and PSO-RBFNN during the iteration process. The F1 value of ISSA-BPN reaches 0.942. The F1 value of GA-BPNN is 0.908, 0.034 lower than ISSA-BPN. F1 value of PSO-RBFNN is 0.896, 0.048 lower than ISSA-BPN. The above data can show that the performance of ISSA-BPN proposed in the study is better than GA-BPNN and PSO-RBFNN in CTQE.

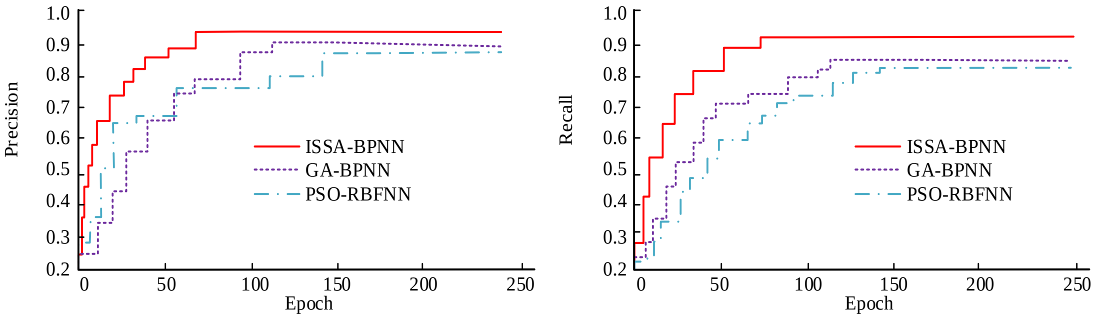


（a）ISSA-BPNN （b）GA-BPNN



（c）PSO-RBFNN

Fig. 4. Difference between model output forecast result and sample actual value.



(a) Precision (b) Recall

Fig. 5. Precision and recall of the model.

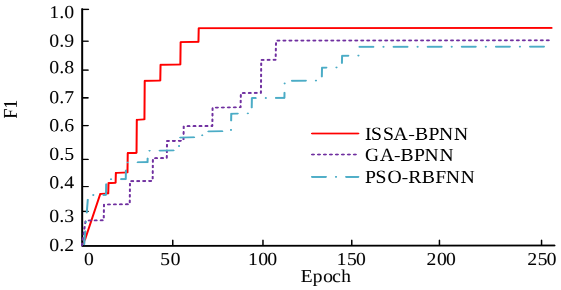


Fig. 6. F1 of the model.

The performance of ISSA-BPN, GA-BPNN and PSO-RBFNN is evaluated by ROC curve. The AUC values of each are shown in Fig. 7. The AUC value of ISSA-BPN is 0.967, 0.014 and 0.025 higher than GA-BPNN and PSO-RBFNN respectively. To sum up, the ISSA-BPNCTQE proposed in the study has good performance and can achieve intelligent evaluation of CT quality with high efficiency and accuracy, thus providing a basis for CT improvement. It has positive significance for the improvement of students' calligraphy level and the inheritance and development of Chinese calligraphy culture.

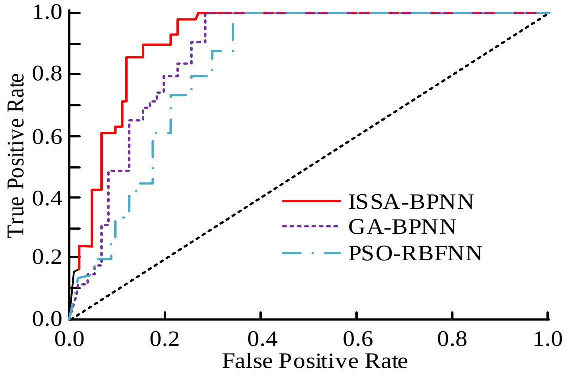


Fig. 7. AUC value of the model.

V. DISCUSSION

Calligraphy teaching plays an important role in the development of traditional Chinese culture. In order to overcome the problems of low efficiency and non-objectivity in traditional CTQE methods, an optimized BPNN model was introduced based on the self-developed CTQE evaluation system, aiming to improve the quality of calligraphy teaching and learning efficiency. In order to verify the performance of the optimized BPNN model, the Rate of convergence, fitness, accuracy, recall, F1 value and AUG value of the model are compared and analyzed in the result analysis part. The application of research methods involves rough sets, principal component analysis, sparrow search algorithm, and BPNN algorithm. Research can be applied not only to the quality evaluation of calligraphy teaching, but also to the quality evaluation of teaching in other disciplines. The method chosen by the research institute can greatly improve the efficiency of evaluating the quality of calligraphy teaching and enhance the objectivity of the evaluation results. The author believes that the development of algorithm technology has brought convenience to people's daily work, and people should effectively utilize it and continuously empower traditional work.

VI. CONCLUSIONS

At present, the main method of CTQE is based on expert opinions and student feedback, which is extremely inefficient and the evaluation results are often not objective. To solve this problem, DL is introduced and an intelligent evaluation of CT quality based on ISSA-BPNN is constructed. The performance of ISSA-BPN is tested using the relevant data of calligraphy major in a university. ISSA-BPN only needs 71 iterations to achieve the best performance, 42 and 71 times less than GA-BPNN and PSO-RBFNN respectively. The loss value of ISSA-BPN is 0.21, which is 0.23 and 0.30 lower than GA-BPNN and PSO-RBFNN respectively. The fitting degree of ISSA-BPN reached 0.953, 0.020 higher than GA-BPNN and 0.051 higher than PSO-RBFNN. Its evaluation accuracy is 95%, 5% higher than GA-BPNN and 10% higher than PSO-RBFNN. Its Precision value is 0.945, 0.142 higher than GA-BPNN and 0.208 higher than PSO-RBFNN. The Recall value of ISSA-BPN is 0.923, 0.213 higher than GA-BPNN and 0.230 higher than PSO-RBFNN. Its F1 value reaches 0.942, 0.034 higher than GA-BPNN and 0.048 higher than PSO-RBFNN. Its AUC value is 0.967, 0.014 and 0.025 higher than GA-BPNN and PSO-RBFNN respectively. To sum up, the ISSA-BPNCTQE proposed in the study has good performance and can achieve intelligent evaluation of CT quality with high efficiency and accuracy, thus providing a basis for CT improvement. It has positive significance for the improvement of students' calligraphy level and the inheritance and development of Chinese calligraphy culture. However, there are also certain shortcomings in the research. During the experimental process, this study only used relevant calligraphy historical data from one university. This may lead to some randomness in the experimental results. Therefore, it is necessary to expand the research scope and include more universities in subsequent research to eliminate this randomness.

ACKNOWLEDGMENT

The research is supported by: Scientific research Project of Shaanxi Provincial Education, A Study on the contemporary Aesthetic Education Value of ancient Tablet Calligraphy in Eastern Qin, (NO., 17JZ031).

REFERENCES

[1] Li, K. W. (2021). Switching to a synchronous mode of Chinese calligraphy teaching during the period of COVID-19 pandemic: An experience report. Electronic Journal of e-Learning, 19(1), 18-20.

[2] Peng, M., Zhang, H. (2022). New Challenges and Countermeasures of Calligraphy Education in Colleges and Universities in the New Era. Creative Education, 13(8), 2544-2552. https://doi.org/10.4236/ce.2022.138161.

[3] Zhang, H., Peng, M. (2022). On the Value Orientation of Calligraphy Education in Colleges and Universities in Multimedia Era. Creative Education, 13(9), 2745-2753. https://doi.org/10.4236/ ce.2022.139173.

[4] Wang, P., Fan, E., Wang, P. Comparative analysis of image classification algorithms based on traditional machine learning and deep learning. Pattern Recognition Letters, 2021, 141, 61-67. https://doi.org/10.1016/j.patrec.2020.07.042.

[5] Ranganathan, G. (2021). A study to find facts behind preprocessing on deep learning algorithms. Journal of Innovative Image Processing (JIIP),

3(01), 66-74. https://doi.org/10.36548/jiip.2021.1.006.

[6] Fang, K. (2022). Research on the Improvement and Refining of the Bachelor Curriculum of Chinese Calligraphy in Colleges and Universities. International Journal of Social Science and Education Research, 5(2), 65-74. https://doi.org/10.6918/IJOSSER.202202_5(2).0012.

[7] Liu, L., Liu, J. (2021). The Teaching Reform and Exploration of the Calligraphy Major Investigation Courses in Colleges and Universities under the Background of the New Liberal Arts. Scientific and Social Research, 3(4), 199-203. https://doi.org/10.36922/ssr.v3i4.1251.

[8] Huda, N., Akbar, F. I. (2022). Analysis of Learning Calligraphy in the Perspective of the Domain of Bloom-Revised Taxonomy. al Mahāra: Jurnal Pendidikan Bahasa Arab, 8(2), 293-318. https://doi.org/10.14421/almahara.2022.082-06.

[9] Sun, L., Shi, C. (2022). Calligraphy Studio Multidimensional Help Environmental Design Professional Talent Training--A Case Study of Anhui University of Finance and Economics. International Journal of Social Science and Education Research, 5(4), 587-592. https://doi.org/10.6918/IJOSSER.202204_5(4).0094.

[10] Liu, X., Gee, L. L. S. (2022). A study of calligraphy aesthetics in contemporary Chinese films. Psychiatria Danubina, 34(suppl 4), 565-565.

[11] Huda, S., Funabiki, N., Kuribayashi, M., Kao, W. C. (2020). A proposal of calligraphy learning assistant system with letter portion practice function using projection mapping. International Journal of Web Information Systems, 16(2), 137-149. https://doi.org/10.1108/IJWIS-07-2019-0032.

[12] Kobayashi, R., Katsura, S. (2022). A generative model of calligraphy based on image and human motion. Precision Engineering, 77, 340-348. https://doi.org/10.1016/j.precisioneng.2022.06.006.

[13] Jin, T. (2022). Creative application of calligraphy and painting art elements in the design of cultural and creative products from the perspective of aesthetic psychology. Psychiatria Danubina, 34(suppl 4), 399-399.

[14] Xi, H., Li, Z., Han, J., Shen, D., Li, N., Long, Y., Chen, Z., Xu, L., Niu, D. (2022). Evaluating the capability of municipal solid waste separation in China based on AHP-EWM and BP neural network. Waste Management, 139, 208-216. https://doi.org/10.1016/j.wasman.2021.12.015.

[15] Liao, H. C., Liao, H. C., Gao, Y., Gao, Y., Wang, Q. G., Dan, W. (2021). Development of viscosity model for aluminum alloys using BP neural network. Transactions of Nonferrous Metals Society of China, 31(10), 2978-2985. https://doi.org/10.1016/S1003-6326(21)65707-2.

[16] Wen, L., Yuan, X. (2020). Forecasting CO_2 emissions in Chinas commercial department, through BP neural network based on random forest and PSO. The Science of the Total Environment, 718(May20), 137194.1-137194.14. https://doi.org/10.1016/j.scitotenv.2020.137194.

[17] Chang, Y., Yue, J., Guo, R., Liu, W., Li, L. (2020). Penetration quality prediction of asymmetrical fillet root welding based on optimized BP neural network. Journal of Manufacturing Processes, 50, 247-254. https://doi.org/10.1016/j.jmapro.2019.12.022.

[18] Li, Q., Wu, J., Chen, Y., Gao, S., Wu, Z. (2020). A new response approximation model of the quadrant detector using the optimized BP neural network. IEEE Sensors Journal, 20(8), 4345-4352. https://doi.org/10.1109/JSEN.2019.2963050.

[19] Song, S., Xiong, X., Wu, X., Xue, Z. Z. (2021). Modeling the SOFC by BP neural network algorithm. International Journal of Hydrogen Energy, 46(38), 20065-20077. https://doi.org/10.1016/ j.ijhydene.2021.03.132.

[20] Han, J. X., Ma, M. Y., Wang, K. (2021). Product modeling design based on genetic algorithm and BP neural network. Neural Computing and Applications, 33, 4111-4117. https://doi.org/10.1007/s00521-020-05604-0.

[21] Li, T., Sun, J., Wang, L. (2021). An intelligent optimization method of motion management system based on BP neural network. Neural Computing and Applications, 33, 707-722. https://doi.org/10.1007/s00521-020-05093-1.