Research on Recommendation Model of College English MOOC based on Hybrid Recommendation Algorithm

Yifang Ding*, Jingbo Hao
North China Institute of Aerospace Engineering
School of Foreign Languages
Langfang, 065000, China

***Abstract*—Establishing a reasonable and efficient compulsory education balance index system is very important to boost the all-around of compulsory education development, and then realize the course recommendation for students with different attributes. Based on this, the research aimed at the problems in college English education and evaluation, aimed to establish a college English MOOC education and evaluation system based on the improved neural network recommendation algorithm. The research first constructed the college English MOOC education and evaluation data elements, and then established a genetic algorithm improved neural network algorithm (BP Neural Network Optimization Algorithm Based on Genetic Algorithm, GA-BP), and finally analyzed the effect of the assembled model. These results show that the fitness of the GA-BP model reaches the set expectation when the evolutionary algebra reaches 10 times, and its fitness is 0.6. The corresponding threshold and weight are obtained, and the threshold and weight are substituted into the model. After repeated iterative training, the model finally reached an error of 10-3 when it was trained 12 times, and the expected accuracy was achieved. The R value of each set hovered around 0.97, and the fitting degree was high, which showed that the GA-BP model proposed in the study had a better fitting degree. The difference between the expected value and the output value is mainly distributed in the [-0.08083, 0.06481] interval. To sum up, the GA-BP model proposed in the study has an excellent effect on college English education and evaluation. This evaluation model has a faster learning rate and a higher prediction accuracy and more stable performance.**

Keywords*—Genetic algorithm; education quality assessment; BP neural network; college English MOOC

I. INTRODUCTION

With the advent of the Internet age, due to the continuous increase of users, the amount of digital information has increased rapidly, and it is difficult for traditional technical means to process it in a short period of time, resulting in information overload [1]. At present, information overload is an urgent problem to be solved. Traditional information retrieval methods cannot quickly and accurately find the most valuable learning resources from massive data [2]. The existing teaching methods cannot fully stimulate the subjects' interest in learning. The above characteristics of the recommendation system can quickly improve the user's retrieval speed for information, and at the same time ensure the validity of the information obtained by the user in the recommendation system. It eliminates the distraction of users during use and improves the credibility of users [3]. In terms of learning and teaching, introducing the recommendation system into the learner's learning situation can make it easier for the subjects to obtain appropriate learning resources, so that the subjects can learn more focused and in-depth [4-5]. MOOC stands for Massive Open Online Course, also known as Massive Open Online Course. MOOC is a curriculum system with a large number of participants, no admission conditions, and an online carrier. Due to the high technical requirements of platforms that support large-scale registration for the operation of MOOC, it is difficult for a university to independently complete it. Therefore, in the MOOC process of implementing blended English teaching in universities, internationally mature MOOC platforms such as China University MOOC and Xuetang Online can be utilized, and teaching materials can be reasonably selected and rigorously designed based on actual teaching needs. Based on this, the study proposes a college English MOOC education and evaluation system based on the improved neural network recommendation algorithm, which can then realize the evaluation of MOOC courses and recommend corresponding courses to students with different attributes. The paper constructs a data mining algorithm and establishes a corresponding system. Based on this, it proposes an improved neural network model. The first part of the paper is an introduction, which introduces the background and motivation of the research; The second part is a literature review, summarizing the research of relevant scholars in different fields; The third part is the research method, which constructs the data mining algorithm in college English education and evaluation system, including the establishment of college English education and evaluation data elements, and the improved neural network algorithm based on genetic algorithm; The fourth part is the analysis of the application effect of improved neural network algorithms in college English MOOC education and evaluation; The fifth part is the conclusion, and the last part is the references.

II. RELATED WORK

Chinese and foreign scholars have conducted extensive discussions and researches on this. Features based on artificial intelligence algorithms. On this basis, in-depth research has been carried out, and it has been widely used in artificial intelligence. Through the simulation experiment of this model, it is proved that this method is correct [6]. Lunde et al in aim of

improving students' subject-related skills, it combines methods such as theoretical education on research topics, proximal validity and validity, and group discussions with social education students on Mental Development of SA-SH-Ext [7]. Sotomayor-Moriano et al. proposed a virtual laboratory environment for online practice using the standard process FDI system. Thanks to VLE, trainees can set the errors of sensors, according to the model of FDI, and perform performance tests on FDI systems. This paper uses a four-pot process (4 TP) FDI system as an example to demonstrate its application under various failure scenarios. At the end of the article, the practical experience of using these two patterns in FDI design is given [8]. Putra et al. collected by questionnaire survey. In the group test there are 9 respondents and in the larger group test there are 12 respondents. It was found that the textbook experts scored 4.06, the media professional scored 4.78, and the language professional scored 4.19, all of which are relatively feasible. The scores for the group test and the large group test are 3.36, 4:21, which shows that this set of materials is very interesting. This set of textbooks can be used as a reference for learning trigonometric functions [9]. Nursalam et al. The purpose of this paper is to conduct a study on the quantum education model established by SDN Salupompong, Level 4, Mamuju Regency, West Sulawesi. This thesis is based on narrative method and sequence method, and carried out 4 investigations and 2 experiments. The study found that in English language learning, students' learning performance was 3.7, while motivation was 3.53, and response to students was 3.44. Among the three effective scales, the effective scale is 3.55, which is a very effective teaching method [10].

Chaves GL et al. through four simulation experiments, the course allows students to explore the effects of glycolysis, TCA cycle, genetic modification on carbon redistribution, and other metabolic pathways. metabolism. there. Students responded positively to using OptFlux as an adaptive questionnaire [11]. Under the concept of "teaching factory", Mourtzis et al. proposed a hybrid model, which has been proven in practice. In the case study of the hybrid power laboratory, engineering students remotely guided the laboratory staff to make and assemble a custom remote-control vehicle. The advantages and limitations of existing methods are discussed, and their development trends are prospected[12]. A manual simulation experiment was conducted to test whether using durable, inexpensive yarn can help pre-med students understand fetal lateral folding. Changes in knowledge are evaluated before and after use. The survey showed that students found the activity to be rewarding and fun, and the model work was easy to carry out. The above research results show that 3D dynamic 3D modeling is an effective teaching method [13]. Sultana et al examines the role of quantitative-based teaching materials in primary school students. Experiments have proved that quantitative teaching methods are more effective than conventional teaching methods in teaching students to think critically. From the critical thinking ability gain test of the experimental class, it can be found that the N-gain value is 0.59. Then, add a new criterion to a test category. The results of the experiment showed that the score of critical thinking in the experimental group increased by 0.20 percentage points compared with the control group. Then, include a gain of n in a lower standard [14]. C Gonzalez-Velasco et al. adopts the flipped classroom teaching method, conducts a comparative analysis of students at different education stages [15].

In order to improve the efficiency of cross-cultural teaching of college English, scholars such as Yin H have constructed an improved MOOC teaching platform based on cloud computing and artificial intelligence technology, and established relevant functional modules. The research results indicate that the model has better performance and can improve the efficiency of English cross-cultural teaching [16]. Yin H proposes a new MOOC remote learning resource recommendation method for college English, which addresses the issue of low efficiency in traditional college English remote education recommendation resources. The interest feedback model is applied to the recommendation system. The research results indicate that this method can improve the accuracy of recommendation results [17].

Therefore, in teaching evaluation, the method of using neural network technology for teaching evaluation is rare, and the application research in college English MOOC teaching and evaluation is even rarer. To this end, in the paper, the neural network model improved by genetic algorithm has been applied in English teaching and evaluation, thus improving the teaching system.

III. Research on Data Mining Algorithms in College English Education and Evaluation System

A. Establishment of College English Education and Evaluation Data Elements

How to evaluate college English teaching should start from the following aspects and analyze the factors affecting English teaching [18].

As can be seen from Fig. 1, the research focuses on the factors affecting the teachers themselves and the factors affecting teaching evaluations from students. It is the influence of the teaching quality evaluation of universities established and selected by the research institute. Factors, and then label them. The order of labeling is from top to bottom. The ten influencing factors are used as the input variable data required by the model below. The specific labeling is shown in formula (1).

$$x = (X_1, X_2, \cdots, X_n)^T \qquad (n = 10) \tag{1}$$

As shown in formula (1), x is the vector of influencing factors of English education and evaluation in colleges and universities X_i, and the value of its influencing factors. According to the relevant factors of English education and evaluation in colleges and universities shown in Fig. 1, experts can obtain the teaching quality level of each college, through the analysis of various influencing factors, the structure of the model of the result is obtained, and the initial value. On this basis, using the number of ANN nodes to find the number of hidden layer nodes. On this basis, combined with the relevant factors of college English teaching and evaluation, the network is trained until the expected training deviation is achieved.

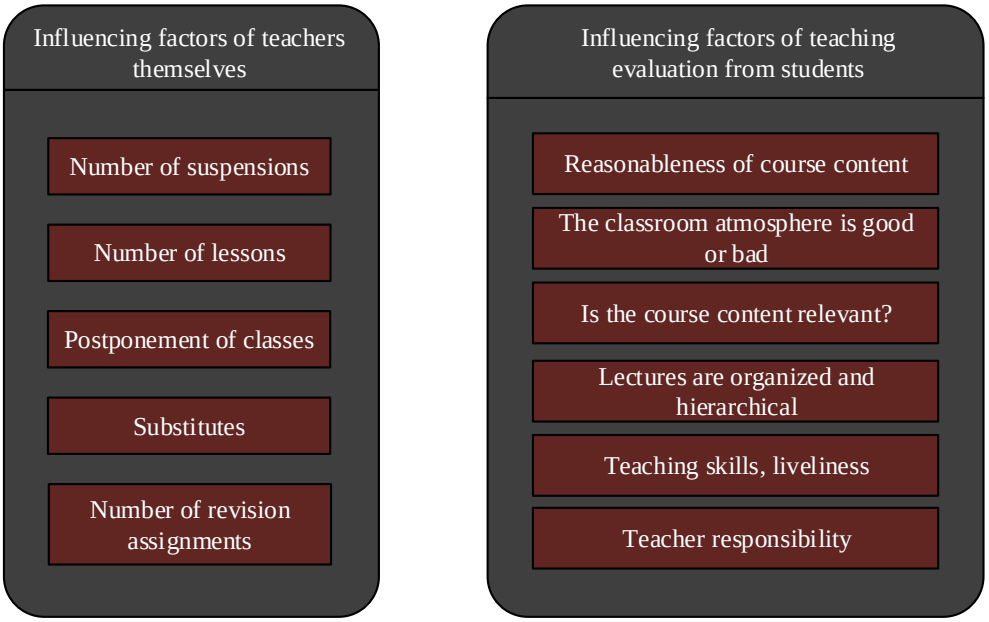


Fig. 1. The influencing factors of teaching quality evaluation in colleges and universities.

B. *Improved Neural Network Algorithm based on Genetic Algorithm*

The BP neural network has similar characteristics to human neurons, and can store a large amount of massive data Input and output training can be performed in the network without knowing the mapping relationship between variables. The basic idea of BP neural network is to reversely modify the forecast of the output layer, so that the deviation between the forecast result and the real data is closer to reality [19]. Its three-level network structure is shown in Fig. 2.

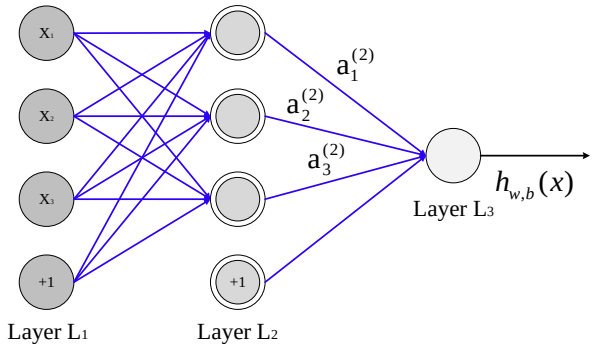


Fig. 2. Three-layer neural network topology.

As shown in Fig. 2, the BP neural network is divided into two stages: pre-activation and activation. Substituting it into the activation function [20], its mechanism and function are shown in formula (2) and formula (3).

$$g(x) = w_{ij} x_i + b_j \tag{2}$$

$$h(x) = f(g(x)) \tag{3}$$

In formula (2) and formula (3), x_i represents i the output value of the first neuron of the previous layer, w_{ij} represents the weight of the first neuron of the upper layer and the first j neuron of the previous layer, and represents the weight i of the first b_j neuron of this layer. j The critical threshold of the element, the relationship between its output $x_j^{'}$ and n input $x_1, x_2, \cdots, x_N$ can be expressed as formula (4).

$$X_j = \sum_{i=1}^{N} w_i \cdot x_i + S_j \tag{4}$$

In formula (4), S_j is the feedback signal. The BP neural network performs an iteration from the forward and backward directions, that is, starting from the input layer, performing continuous operations on the existing parameters, and then transmitting to the output layer along the forward direction of the network, and predicting it, and calculated its actual loss. The reverse transmission refers to the deviation between the previous forecast and the actual loss. The BP neural network performs an iteration from the forward and backward directions, that is, starting from the input layer, performing continuous operations on the existing parameters, and then transmitting to the output layer along the forward direction of the network, and predicting it, and calculated its actual loss. Backpropagation refers to the loss error between the predicted value and the real value obtained last time. Starting from the output layer, Using the gradient descending method, the parameters of each layer are reversely corrected until the deviation between the actual loss and the actual loss of each layer is the target [21]. The specific operation steps are shown in Fig. 3.

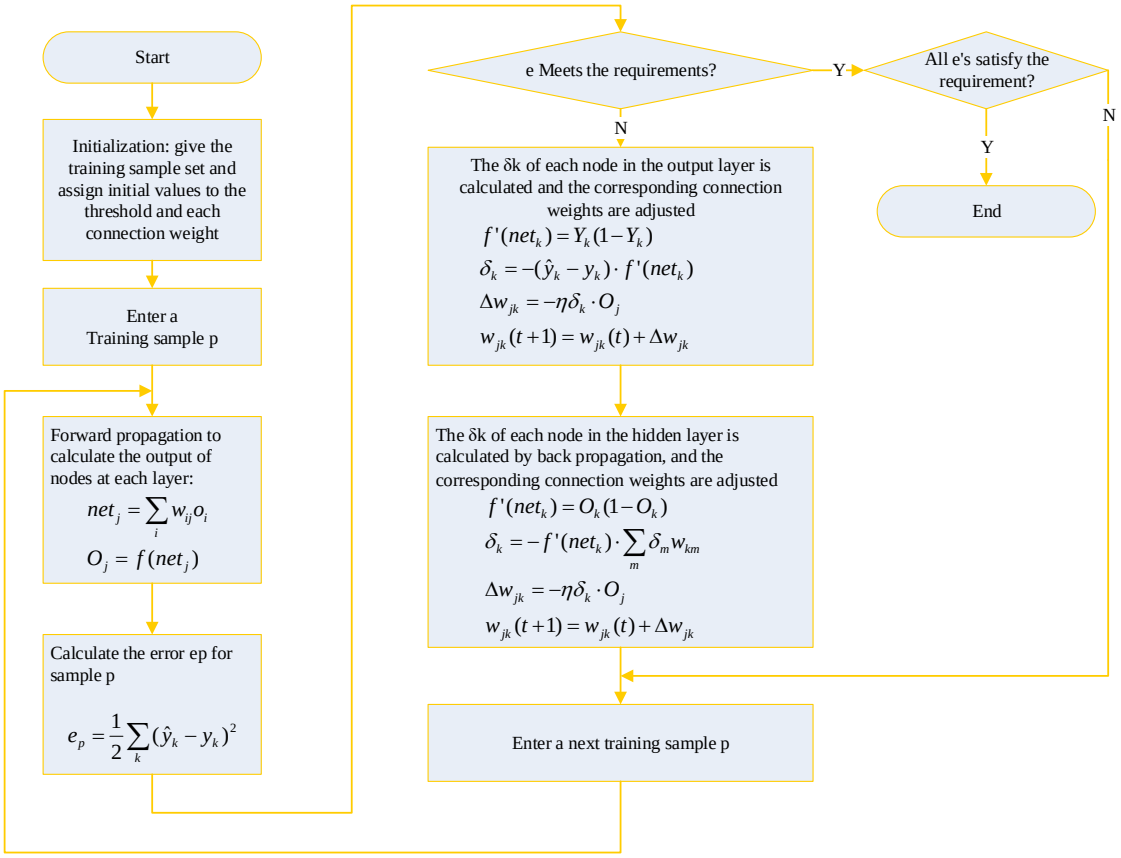


Fig. 3. BP neural network training flow chart.

Hidden layer output variable is shown in formula (5).

$$h_j = (h_1, h_2 \cdots, h_p) = f(\sum_{i=1}^{n} w_{ij} x_i + a_j),\ j = 1, 2, \cdots, p \tag{5}$$

In formula (5), a_j is the bias, and the actual output variable of the output layer is shown in formula (6).

$$y_k = (y_1, y_2, \cdots, y_q) = \sum_{j=1}^{p} h_j w_{jk} + b_k, k = 1, 2, \cdots, q \tag{6}$$

In Equation (7), the expected output variable of the output layer is shown in Equation (8).

$$d_k = (d_1, d_2, \cdots, d_q), k = 1, 2, \cdots, q \tag{7}$$

The error function is shown in formula (8).

$$E = \frac{1}{2}\sum_{k=1}^{q} (d_k - y_k)^2 \tag{8}$$

Assuming m training samples, the error function is shown in formula (9):

$$E = \frac{1}{2m}\sum_{l=1}^{m}\sum_{k=1}^{q} (d_k(l) - y_k(l))^2 \tag{9}$$

weight update formula is shown in formula (10).

$$\begin{cases} w_{ij} = w_{ij} + \eta h_j (1-h_j) x_i \sum_{k=1}^{q} w_{jk}(d_k - y_k) \\ w_{jk} = w_{jk} + \eta h_j (d_k - y_k) \end{cases} \tag{10}$$

In formula (10), η is the learning rate, and the update formula of the bias is shown in formula (11).

$$\begin{cases} a_j = a_j + \eta h_j (1-h_j) \sum_{k=1}^{q} w_{jk}(d_k - y_k) \\ b_k = b_k + \eta (d_k - y_k) \end{cases} \tag{11}$$

In the 1970s, genetic algorithms were introduced into computers and achieved great success in many practical problems in the 1980s, thus arousing great interest from people. Genetic algorithm refers to and imitates the genetic mechanisms and natural selection of organisms, adopting a "survival of the fittest" approach to continuously evolve the solution to a problem in competition, ultimately obtaining a satisfactory solution. It screens out random information exchange and fragments with strong adaptability in the sequence of the previous generation and reconstructs them into a new population, which is called "survival of the fittest". Sometimes new bits and fragments are added to the sequence, which is called "variation". By performing genetic operations such as selection, crossover, and mutation on the population, the optimization degree of the population during the evolution

process is continuously improved, ultimately approaching global optimization. Genetic algorithm has the advantages of global optimization, while BP neural network has better local search performance. However, since the BP network is randomly given the initial weight value, it will cause a situation. After the BP training, the total weight of each training and the total weight are different. In order to improve the quality of English teaching, this paper uses BP neural network and genetic algorithm to establish a new teaching evaluation system. In the weight optimization of the neural network, first initialize the group P and determine the size of the initial group; the second step is to sort the fitness function of each person, and then determine the individual in the network according to the probability value [22]. The selection method is shown in formula (12):

$$P_i = f(i) / \sum_{i=1}^{n} f(i) \tag{12}$$

In formula (12), is $f(i)$ the fitness of individual i ; The third step is to cultivate a new generation of individuals through genetic modification, and eliminate unqualified parents; the fourth step is to eliminate the new generation of individuals, insert them into the original population P, and perform fitness function calculations on them, and then use the error of the neural network to determine whether it meets the expectation, if it is satisfied, go to the sixth step; otherwise, go to step 3 and perform genetic manipulation; the sixth step, according to the error accuracy required by the neural network, on this basis, the best individual is selected as the weight of the neural network and operated on[23-24]. The probability of selecting individual i is shown in formula (13).

$$P_i = f_i / \sum_{k=1}^{M} f_k \tag{13}$$

Formula (13), the initial population is M and the fitness of individual i is f i. After obtaining the probability of each individual, it will determine which individuals to mate with by random numbers between [0,1] Activities [21]. Since the interleaving mode has a great relationship with the actual coding situation, this article only discusses the coding method of floating-point numbers, and the form of arithmetic interleaving is as formula (14)[25].

$$\begin{cases} X_A^{t+1} = \partial X_B^t + (1-\partial) X_A^t \\ X_B^{t+1} = \partial X_A^t + (1-\partial) X_B^t \end{cases} \tag{14}$$

Formula (14), X is an individual and ∂ a parameter. If it is constant, it is an equation operation. If it is determined by evolutionary algebra, it is inconsistent. The last one is mutation, which uses the method of uniform mutation. Homogeneous mutation is to replace the gene values of all genes on a single chromosome with random numbers that conform to the average distribution with a certain probability[26]. The gene on each chromosome is regarded as a change point, and then according to different mutation points, the initialization and termination of the genetic algorithm will be iterated repeatedly, and fitness calculation, replication and crossover will be performed in each iteration, genetic operation, such as a mutation, will not stop repeating until the end condition is reached[27]. Depending on the actual situation, different applications will have different end conditions. The end condition of this article is that it will stop when the number of repetitions is reached. The flowchart of the GA-BP neural network algorithm is shown in Fig. 4.

The initial value is compared with the adaptive function of BP neural network; obtain new populations through operations such as crossover and mutation until the goal is optimized, and then repeat the genetic operation until the genetic iteration is completed. By optimizing the BP neural network[28]. On this basis, the optimal initial value and minimum threshold can be obtained. This method mainly includes the initial and threshold of BP neural network, the learning and experiment of BP neural network[29-30]. Finally, the average cross-entropy of the verification set is calculated, and the model with the smallest average cross-entropy error of the verification set is determined as the final evaluation model, see formula (15).

$$Acc = \frac{1}{k} \sum_{i=1}^{k} acc_i \quad (i = 1, 2, \ldots, k) \tag{15}$$

In formula (15), acc_i is the cross-entropy error of the first i verification set. Finally, the accuracy rate of college English teaching evaluation quality evaluation is recorded as formula (16).

$$P = \frac{N_{right}}{N_{all}} * 100\% \tag{16}$$

In Equation (16), N_{right} is several factors affecting the quality of English teaching, and N_{all} is the total number of items in the test set. Common accuracy evaluation indicators include recall rate (Recall) and F1 value[31-32]. The calculation method is shown in the formula (17) and formula (18).

$$\mathrm{Re}call = \frac{TP}{TP + FN} \tag{17}$$

$$F1 = \frac{2 * Precision * \mathrm{Re}call}{\left(Precision + \mathrm{Re}call\right)} \tag{18}$$

Formulas (17) and (18), it TP represents the number of the samples that were actually positive and those that were predicted to be positive, referred to as true positive numbers, and so on TN, FP, FN are true negative numbers, false positive numbers, and false negative numbers[33-34]. Considering that in English teaching, it is of great significance to identify correct pronunciation and wrong pronunciation, so the accuracy rate is selected as the performance evaluation index of each model.

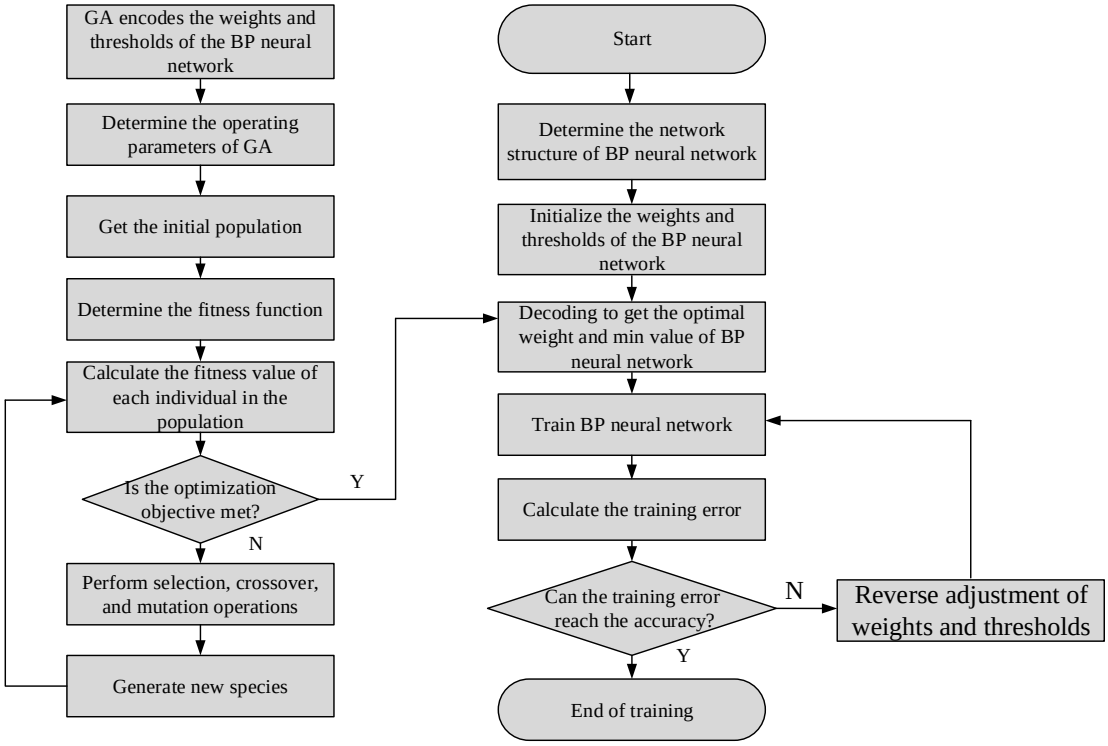


Fig. 4. GA-BP neural network algorithm flow chart.

IV. Application Effect Analysis of Improved Neural Network Algorithm in College English MOOC Education and Evaluation

The study uses ten evaluation indicators of five universities as the input data of this study, and vectorizes the time to obtain the relevant teaching measurement score input matrix. Due to the difference in the dimension of each indicator, the deceleration rate of each indicator is different; adopting the same learning rate makes it difficult for the network training to achieve the optimal solution. At the same time, it avoids the gradient explosion caused by the index data with too large value, and the index with too small value is swallowed. Among them, in the experiment, the memory of each algorithm was 512Mb, the encoding tool was C++, and the operating system was Windows XP.The learning of BP network is an important content of BP neural network. In order to ensure the consistency of the distribution of numbers and models, this paper proposes a unified standard to combine the training set with the test set and standardize the data. Table I shows the details after normalization.

In the process of establishing the model, the Sigmoid function and the tanh function carry out the input data in the interval [0,1]. Most of them are in a suppressed state, and the differential interval is below 1. The gradient value shows an exponential decline with the increase of network depth, and there may be a gradual phenomenon. The Relu function is activated when the input value exceeds 0. It has a wide activation range and can well avoid the gradient disappearance phenomenon in network training. Neither the Reluc function nor the Reluc differential has performed any complicated mathematical operations, and will it be directly set to 0, thereby avoiding the participation of restricted neurons, thus making the learning of the neural network faster. However, Relu sets the initial state of the neuron to 0, so that it cannot perform subsequent operations, thus causing damage to the neuron during the learning process. Leaky_Relu is a modification of the Relu function, setting the inhibition state of Relu to a very small parameter α, which can well alleviate the weakness of the neural network. It needs to be adjusted continuously through network training, and α the setting is not easy to master. On this basis, different training errors and training times are obtained, as shown in Table II.

TABLE I. Normalized Data

-	x1 _	x2 _	x3 _	x4 _	x5 _	X 6	X 7	X 8	X 9	X 10
School 1	0.11	0.21	0.54	0.54	0.43	0.19	0.55	0.61	0.54	0.63
School 2	0.13	0.35	0.32	0.38	0.13	0.36	0.19	0.35	0.64	0.38
School 3	0.68	0.18	0.48	0.21	0.23	0.81	0.81	0.31	0.94	0.72
School 4	0.61	0.16	0.39	0.64	0.78	0.44	0.52	0.25	0.15	0.14
School 5	0.54	0.09	0.21	0.64	0.46	0.64	0.64	0.12	0.11	0.52

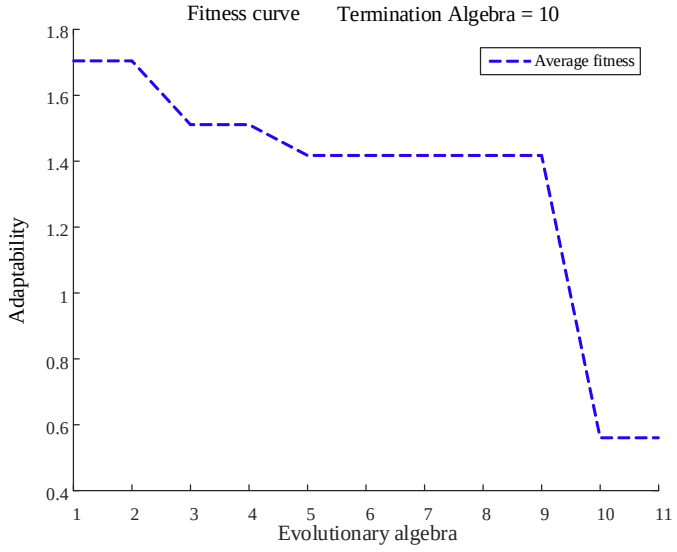
TABLE II. COMPARISON OF EXPERIMENTAL RESULTS BETWEEN RELU FUNCTION AND LEAKY_ RELU FUNCTION

-	Relu function		Leaky_Relu function	
	Training error	Training time	Training error	Training time
The first time	0.0218	105	0.0238	118
The second time	0.0235	102	0.0240	123
The third time	0.0216	101	0.0209	109
The fourth time	0.0211	102	0.0210	115
fifth time	0.0219	103	0.0256	117

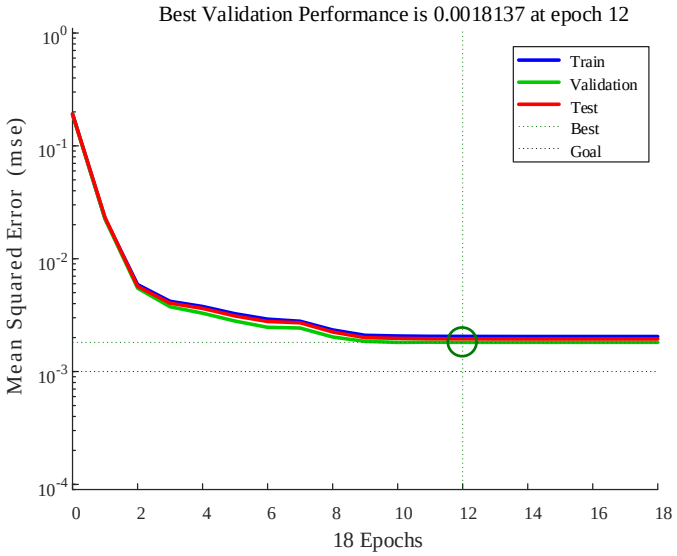
The BP neural network uses the Relu function as the initial function. BP neural network has a high recognition rate in the (0,1) interval. The output of the BP neural network is the graded gradient of the quality of school education, and its grade gradient is 0~8, which belongs to multi-category problems. Generally, it is a softmax function. This function is the probability of mapping the output of multiple neurons to the (0,1) interval, and the total probability sum of each neuron is 1. After determining the GA-BP model, import the normalized data into the model for further analysis, and first obtain its fitness curve and the training error curve of the neural network, as shown in Fig. 5.

As shown in Fig. 5, the improved BP neural network model of the genetic algorithm has the desired accuracy; as shown in Fig. 5(a), when the fitness value is 10 times, the evolution algebra of the GA-BP model is 10 times. The set expectation has a fitness of 0.6, and the corresponding threshold and weight are obtained. As shown in Figure 5(b), the threshold and weight are substituted into the model, and repeated iterative training is carried out. Finally, when the training reaches 12 times, the model error of 10 -3 was achieved, achieving the expected accuracy. The error histograms of each set are shown in Fig. 6.

As can be seen from the graph, the error of the training set is mainly concentrated at the zero point, and the difference between the expected and output is mainly at [-0.08083,0.06481]. The predictor results show that the model based on the GA-BP neural network has a higher predictive ability and better stability.



(a)Fitness curve of GA-BP neural network



(b)Graph of the training result of GA-BP neural network

Fig. 5. GA-BP neural network training performance renderings.

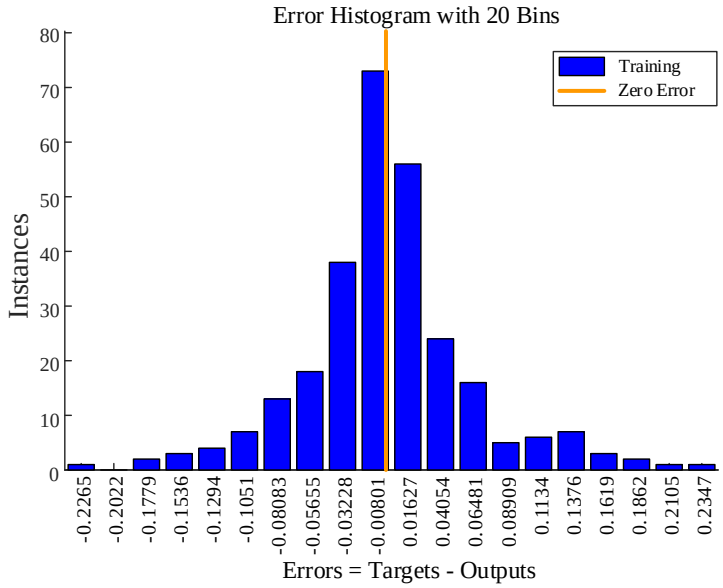


Fig. 6. The training error histogram of GA-BP neural network.

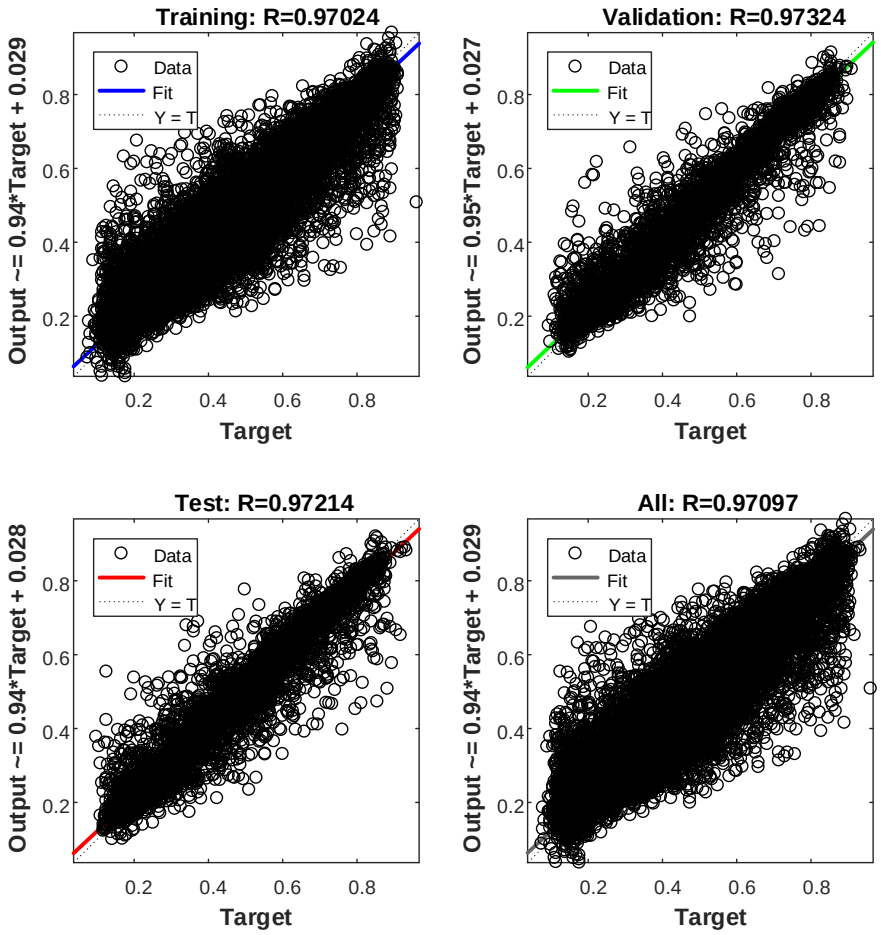


Fig. 7. Fitted curve after training.

Can be seen from Fig. 7 that the predicted value of the training set is relatively high, and deviations will occur in a few cases. The R values of each set hover around 0.97, and the fitting degree is high. The R value of the training set is 0.97024. The results show that the fitting effect of the GA-BP model established in this paper is better. By comparing the BP network and the GA-BP network, a conclusion similar to that in Fig. 8 is drawn.

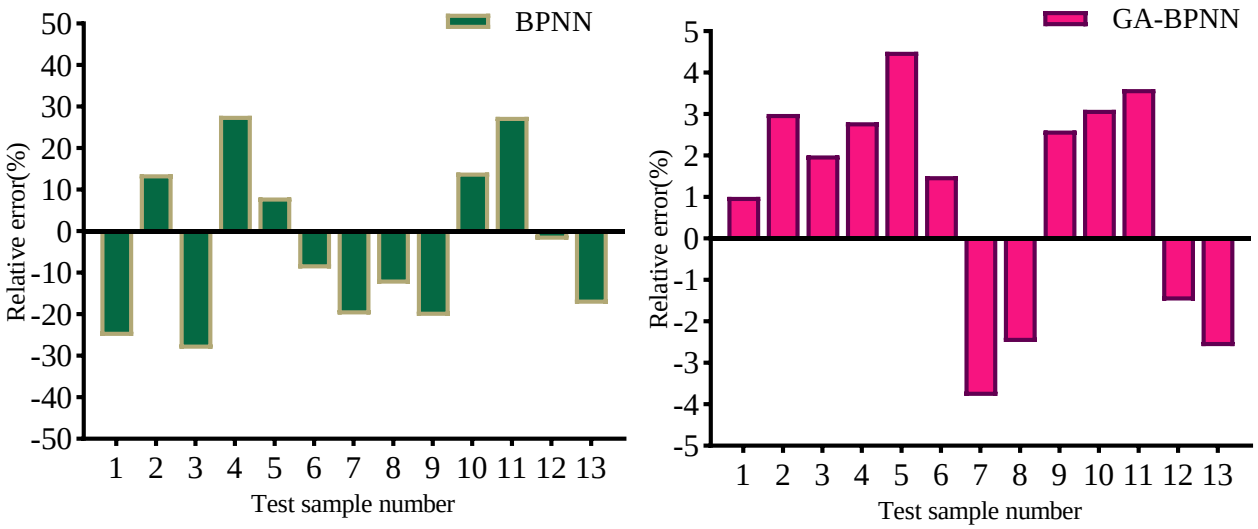


Fig. 8. The average relative error of the two models.

From the relative error histogram in Fig. 8, it can be clearly seen that the absolute value of the relative error of the GA-BPNN model proposed in this study does not exceed the 5% limit of each evaluation index. Only the relative errors of individual evaluation indicators have big problems, their values are 4.52% and -3.84%, and the relative errors of other indicators are kept at a low level, and their errors are much smaller than those of the BPNN model. The GA-BP model proposed in the study has an excellent effect on college English education and evaluation. This evaluation model has a faster learning rate, higher prediction accuracy and more stable performance.

V. CONCLUSION

Under the current education model, traditional English learning methods are mostly teaching-based. Fostering student autonomy is a hot topic in education at the moment. How to let students focus more and learn in a broader range has also become a topic for scholars—the focus of attention. In the traditional classroom environment, with classrooms and libraries as the main body, the emergence of multimedia classrooms has increased the diversity of classroom teaching to some extent due to the wide application of computers. To ensure the fairness of compulsory education, it is highly relevant in terms of assessment of the teaching quality of the College English MOOC. This thesis aims to introduce genetic algorithm into college English teaching and evaluation and improve it. Deviations between the expected and the real values are essentially [-0.08083, 0.06481]. It can be known that the prediction performance of the model is robust. The R values of each set hover around 0.97, and the fitting degree is high. Finally, a comparative analysis of the relative prediction errors of the two models shows that the absolute value of the relative error of the proposed GA-BP model does not exceed that of each evaluation. The limit value of 5% of the index is better than a single algorithm. In short, the research can reflect the actual situation of delivering and assessing English in colleges and universities., and has substantial practical application value.

REFERENCES

[1] X. Jia, “A Review of the Teaching Model of Mental Health Education Courses in Primary and Secondary Schools in the New Media Environment.” Education Study, , vol. 3(2), pp. 225-227, 2021.

[2] M. Abdullah, S. B. Thalib, G. D. Dirawan, “The Quality of Integrating, Rationale & Approach Participation (IRA) Teaching Model Based on Environmental Education: A Research & Development.” Universal Journal of Educational Research, 2021, vol. 9(8), pp. 1560-1571, 2021.

[3] C. A. Salazar, C. I. Cantillo, H. Muoz, “Contribution of the implementation of an alternative teaching model in the teaching of mathematics: solving arithmetic problems in primary basics.” Espacios, vol. 42(1), pp. 119-130, 2021.

[4] J. Wexler, C. Lyon, E. K. Hogan, M. Devin Kearns. “Individualizing Literacy Instruction in Co-Taught Classrooms Through a Station Teaching Model.” Intervention in School and Clinic, 2021, vol. 56(4), pp. 224-232, 2021.

[5] C. Jiny, M. You-Mi, “A Study on the Development of Pedagogic Corpus and Suggestions for Teaching Model Using it: Focused on the Low-intermediate Students.” Chinese Studies, 2020, vol. 71, pp. 221-242, 2020.

[6] Y. Wang, “Ideological and political teaching model using fuzzy analytic hierarchy process based on machine learning and artificial intelligence”. Journal of Intelligent and Fuzzy Systems, 2020, vol. 40(6), pp. 1-13, 2020.

[7] G. H. Lunde, A. Bakke, K. Areskoug-Josefsson. “Piloting a Research-Oriented Teaching Model in a Bachelor Program for Social Educators – A Way to Increase Competence in Research Methodology and Sexual Health.” Uniped, 2020, vol. 43(3), pp. 260-274, 2020.

[8] J. Sotomayor-Moriano, G. Pérez-Zúiga, M. Soto, “Teaching Model-based Fault Detection and Isolation using a Virtual Laboratory Environment.” IFAC-PapersOnLine, 2020, vol. 53(2), pp. 17350-17355, 2020.

[9] R. Putra, S. Suherman, B. S. Anggoro. “Alqurun Teaching Model-Based Trigonometry Teaching Material.” Indonesian Journal of Science and Mathematics Education, 2020, vol. 3(2), pp. 219-227, 2020.

[10] M. Nursalam, H. E. Fitriana, J. Jusmawati, “Efektifitas Model Quantum Teaching Terhadap Pembelajaran Mathematica Siswa di Sekolah Dasar.” Journal Basicedu, 2021, vol. 5(2), pp. 506-516, 2021.

[11] G. L. Chaves, R. S. Batista, J. Cunha, “Teaching cellular metabolism using metabolic model simulations.” Education for Chemical Engineers, vol. 38, pp. 97-109, 2022.

[12] D. Mourtzis, N. Panopoulos, J. Angelopoulos. “A Hybrid Teaching Factory Model for Supporting the Educational Process in COVID-19 era.” Procedia CIRP, vol. 104, pp. 1626-1631, 2021.

[13] S. Mcconnell, C. Mooney. “A Crocheted Model Activity for Teaching Embryonic Lateral Folding to Medical Students.” Anatomical sciences education, vol. 14(5), pp. 666-674, 2021.

[14] N. Sutarna, N. Nurfirdaus. “Bahan Ajar Berbasis Model Quantum Teaching Untuk Meningkatkan Kemampuan Berpikir Kritis.” Naturalistic Journal Kajian Penelitian Pendidikan dan Pembelajaran, vol. 4(1), pp. 5.17-42, 2020.

[15] C. González-Velasco, Feito-Ruiz I., M. G. Fernández. “Does the teaching-learning model based on the flipped classroom improve academic results of students at different educational levels”. Revista Complutense de Educacion, vol. 32(1), pp. 27-39, 2021.

[16] Yin H. The recommendation method for distance learning resources of college English under the MOOC education mode. International journal of continuing engineering education and life-long learning, 2022,32(2):265-278.

[17] Xie H, Mai Q. College English cross-cultural teaching based on cloud computing MOOC platform and artificial intelligence. Journal of Intelligent & Fuzzy Systems: Applications in Engineering and Technology, 2021,40(4):7335-7345.

[18] D. G. Bratt, C. Berridge, M. Young, “A simple novel training model for teaching suprapubic catheter (SPC) exchange.” Actas Urológicas Españolas (English Edition), vol. 44(8), pp. 549-553, 2020.

[19] X. Chang, “An Integrated Model of Teaching Theory and Action Research in POA-based Textbook Writing.” Chinese Journal of Applied Linguistics, vol. 43(3), pp. 359-372, 2020.

[20] M. Keller, D. Ritter, L. Schmitt. “Teaching Nonlinear Model Predictive Control with MATLAB/Simulink and an Internal Combustion Engine Test Bench”. IFAC-Papers on Line, vol. 53(2), pp. 17190-17197, 2020.

[21] D. Park, J. Ahn, J. Jang. “The Development of Software Teaching-Learning Model based on Machine Learning Platform.” Journal of the Korean Association of Information Education, vol. 24(1), pp. 49- 57, 2020.

[22] E. Lee, Developing a Low-Cost Microcontroller–Based Model for Teaching and Learning. European Journal of Educational Research, vol. 9(3), pp. 921-934, 2020.

[23] C. Slab, D. Assa, E. Fq, “Use of a virtual 3D anterolateral thigh model in medical education: Augmentation and not replacement of traditional teaching” - ScienceDirect. Journal of Plastic, Reconstructive & Aesthetic Surgery, vol. 73(2), pp. 269-275, 2020.

[24] B. Abdelkader, “Optimization of the Geometric Model Neuronal (BPNN) of a Polyarticulated Arm.” Journal of Advanced Research in Dynamical and Control Systems, vol. 12(4), pp. 1137–1146, 2020.

[25] J. Chen, “DDoS Attack Target Detection Based on AM+BPNN.” Scientific Journal of Technology, vol. 4(8), pp. 45–49, 2022.

[26] H. Fu, Y. Liu. “A deep learning-based approach for electrical equipment remaining useful life prediction”. Autonomous Intelligent Systems, vol. 2(1), pp. 1-12, 2022.

[27] J. Liu, H. Shao, Y. Jiang, X. Deng, “CNN-Based Hidden-Layer Topological Structure Design and Optimization Methods for Image Classification. Neural Processing Letters, vol. 54(4), pp. 2831-2842.

[28] M. Mahboubkhah, A. Barari, M. Aliakbari, “Computer integrated work-space quality improvement of the C4 parallel robot CMM based on kinematic error model for using in intelligent measuring.” International Journal of Computer Integrated Manufacturing, vol. 35(4-5), pp. 444-461, 2022.

[29] J. Pu, Z. Liu. “Analysis and research on intelligent manufacturing medical product design and intelligent hospital system dynamics based on machine learning under big data”. Enterprise Information Systems, vol. 16(2), pp. 193-207, 2022.

[30] J. Zhang, J. Fan, Yang J., J. Yu. “Semisupervised image classification by mutual learning of multiple self-supervised models.” International Journal of Intelligent Systems, vol. 37(5), pp. 3117-3141, 2022.

[31] A. Chen, S. Hong, Y. Wang, C. Li., C. Yang, H. Chen. “Rapid Assessment of Gasoline Quality by near-Infrared (NIR) Deep Learning Model Combined with Fractional Derivative Pretreatment.” Analytical Letters, vol. 55(11), pp. 1745-1756, 2022.

[32] X. Lu, W. Liao, Y. Zhang, Y. Huang. “Intelligent structural design of shear wall residence using physics-enhanced generative adversarial networks.” Earthquake Engineering and Structural Dynamics, vol. 51(7), pp. 1657-1676, 2022.

[33] M. B. Umair, Z. Iqbal, F. Z. Khan, M. Khan, S. Kadry, “A Deep Learning Based Method for Network Application Classification in Software-Defined IoT.” International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, vol. 30(03), pp. 463-477, 2022.

[34] T. A. M. Devi, P. Darwin, “Hyper Spectral Fruit Image Classification for Deep Learning Approaches and Neural Network Techniques.” International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, vol. 30(03), pp. 357-383, 2022.