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Collaborative Innovation in Ecological Art and Landscape Design: A Case Study of Ecological Restoration Art Projects

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Abstract In recent years, with the improvement of people's living standards, the ecological and artistic aspects of landscape design have attracted much attention. The study selects nine wetland restoration art projects in Yangtze River Delta as case studies for analysis and research. Based on the data from the questionnaire survey, gray correlation analysis is used to determine the weights for predicting the synergistic innovation effect of ecological fine arts and landscape design. On this basis, a BP neural network prediction model of collaborative innovation between ecological fine arts and landscape design is constructed, and the feasibility of this paper's method is verified through experimental tests. The results show that there are three high correlation factors for the synergistic innovation of ecological fine arts and landscape design, which are ecosystem stability, adaptive management and ecological function restoration. In the comparison experiments, the average absolute percentage error of the prediction results based on this paper's model is 3.13% lower than that of the time series analysis method, which indicates that the prediction based on this paper's model has better adaptability, real-time and accuracy, and it can be fused with a wide range of data, and the overall prediction performance is better than the traditional statistical methods.

Index Terms gray correlation, BP neural network, eco-art, landscape design

I. Introduction

As an art project with high ecological benefits, ecological restorative art projects can improve the living environment and air quality, help biodiversity, promote social harmony, drive economic development and other advantages [1], [2]. With the concept of sustainable development, the modern ecological landscape design has become more and more closely connected with social development and people's production and life [3]. Under the continuous evolution of sustainable development, ecological art and landscape design are required to continuously innovate and develop in ecological restoration.

Landscape design to a large extent are directly in the change of the environment around us, and this change is due to the size of the project and different degrees of the environment, landscape designers can not be completely scientific to see the design, but the designer must understand the science, understand the ecology [4], [5]. In addition, the beauty of form and vision in landscape design is certainly important, but designers can not only pay attention to the beauty of form and vision in landscape design, but also should take into account whether this design program will damage the environment and ecology, a landscape design works on the ecology and damage to the environment must not be a good work, such a work has a great defect, not in line with the design of the sustainable development strategy [6]-[8].

From the perspective of artistic aesthetics, the aesthetic properties of ecological landscape, can be found that the design of ecological is in line with people's aesthetic value, human beings have a profound understanding of beauty, those advanced things that have a role in promoting human development, those things that can make human beings sustainable development, they embody a kind of positive value, and the things that can embody the positive value are considered to be beautiful by human beings [9]-[12]. Eco-art refers to being based on the discipline of art, realizing the natural, social and humanistic integration with all disciplines, and advocating that students are like natural ecosystems, developing naturally, confidently and freely. Taking this as the starting point, we strive to form a multi-dimensional atmosphere of “openness and freedom, symbiosis and complementarity, penetration and integration”, and form a system of goal ecology, content ecology, methodology ecology and evaluation ecology, so as to achieve the ecology of following the law of the development of things, respecting the human growth, and focusing on the ecology of the mind to internalize the growth of aesthetics [13]-[15]. Due to the lack of macro systematic analysis of the environment, not from the long-term interests to consider, but one-sided massive transformation of the environment, so that ultimately not only did not improve the environment for human survival, but also destroyed the environment, hindering the sustainable development of ecology [16]-[18]. This kind of design without considering the ecology is to consume a lot of energy and human resources, so designers should try to design according to the local geographic and natural environment and ecological environment, and integrate the landscape design into the local ecosystem, so that the water in the landscape can be automatically purified, and the organisms can grow healthily, and maintain the diversity of the local organisms, this kind of landscape design is not only saving energy but also sustainable development, and also maintains the vitality of the landscape [19]-[22].

The article firstly elaborates the principle and application steps of the gray correlation analysis method. Then nine wetland restoration art projects in Yangtze River Delta are selected for case study, and the gray correlation degree method is used to mine 11 co-innovation influencing factors of ecological fine arts and landscape design, and the gray correlation degree of each influencing factor is calculated and ranked, and 10 influencing factors are finally determined. Secondly, the BP neural network theory, structure, algorithm principle and operation process are introduced to construct the BP neural network collaborative innovation effect evaluation model of ecological art and landscape design. Finally, the effectiveness of the model designed in this paper is verified by model performance test.

II. Grey correlation analysis methodology

II. A. Introduction to the methodology of gray correlation analysis

Gray correlation analysis, also known as gray correlation theory, is an approach that uses similarity between statistical series to determine the degree of correlation between multiple series. The more similar the geometry of the curves between two sequences, the higher the degree of association. If a series of influences is compared to a target series, the factor represented by the sequence with the higher degree of correlation is the primary factor, while the factor with the lower degree of correlation is the secondary factor. In this case, the correlation refers to the relative change between the two factors rather than the absolute situation. This calculation approach is to find its potential correlation from different sequences, so as to better inform the prediction accuracy, factor analysis and the final conclusion [23]. Its specific calculation steps are as follows:

(1) Determination of comparison and reference series. In a system, the sequence that affects its behavior is called the comparison series, and the sequence that reacts to the characteristics of its behavior is the reference series. The representation using mathematics is as follows: assuming X_i the system factors of the system, the data represented by the sequence number k can be $X_i(k) = 1,2,3,\cdots,n$, such that $X_0 = Y = \{x_0(k), k = 1,2,\cdots,n\}$ is the reference series. $X_i = \{x_i(k), k = 1,2,\cdots,n, i = 1,2,\cdots,m\}$ is the comparison series.

(2) Standardization. In the process of gray correlation analysis, when the different groups of sequences appear to have a different outline, it is necessary to carry out the dimensionless processing of the data. Generally speaking, this process can be realized by means of initialization, averaging, intervalization and so on. In this paper, the dimensionless processing adopted is the homogenization approach, corresponding to the processing formula is as follows:

The homogenization process for the reference series Y yields Y', which is:

$$Y' = (Y'(1), Y'(2), \cdots, Y'(n)) = \left(\frac{Y'(1)}{\bar{Y}}, \frac{Y'(2)}{\bar{Y}}, \cdots, \frac{Y'(n)}{\bar{Y}}\right)$$
$$\bar{Y} = \frac{1}{n}\sum_{k=1}^{n} Y(k) \tag{1}$$

Homogenizing for the comparison series $X_i(k)$ yields $X_i'(k)$, which is:

$$X_i'(k) = X_i'(1), X_i'(2), \ldots\ldots X_i'(n) = \left(\frac{X_i(1)}{\bar{X}}, \frac{X_i(2)}{\bar{X}}, \ldots\ldots \frac{X_i(n)}{\bar{X}}\right)$$
$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} x_i(k) \tag{2}$$

(3) Gray correlation coefficient. The degree of difference in the shape of the set of curves between the series can measure the correlation between the data series, specifically the difference is the size of the curve difference. The correlation coefficient between the reference series Y' and the comparison series X' at point k is $\varepsilon_i(k)$, resulting in the formula:

$$\varepsilon_i(k) = \frac{\max_1 \max_k |Y' - X_i| + \varepsilon \max_1 \max_k |Y' - X_i|}{|Y' - X_i| + \varepsilon \max_1 \max_k |Y' - X_i|} \tag{3}$$

where ε is the resolution factor, taking values from 0 to 1, and $\varepsilon_i(k)$ is the correlation coefficient of Y' to X_i' at k points in the above equation:

Denote M as the maximum difference between the two levels:

$$M = \max_{1} \max_{k} | Y' - X_i | \tag{4}$$

Denote m as the two-level minimum difference:

$$m = \max_{1} \max_{k} | Y' - X_i | \tag{5}$$

Mark the absolute difference as:

$$\Delta_i(k) = | Y' - X_i | \tag{6}$$

Then the above formula for the correlation coefficient can be abbreviated as:

$$\varepsilon_i(k) = \frac{m + \varepsilon M}{\Delta i(k) + \varepsilon M} \tag{7}$$

(4) Derive the degree of association. As can be seen from the above equation, the degree of association reflects the values of the individual series at different points in time, so there are many of them. In addition, due to the scattered arrangement of multiple pieces of information, this makes visual comparison more difficult as well. In order to be able to reflect the relationship between the columns, the average value can be introduced to measure these columns and use the measurement result as the correlation between the rubbing column and each comparison column, the specific formula is as follows:

$$\varepsilon_i = \frac{1}{n} \sum_{k=1}^{n} \varepsilon_i(k) \tag{8}$$

(5) Correlation ordering. Generally speaking, when analyzing a system, the order of correlation is taken to measure the degree of correlation between different factors in order, not only the value of the correlation itself. In order to make the comparison of the degree of closeness between the comparison sequence and the participating sequences more intuitive, this paper will be based on the correlation degree of the sequences from the largest to the smallest order, and the composition of the correlation order. The correlation degree reflects the degree of closeness of each comparison sequence with respect to the reference sequence.

Of course, it should be noted that the results of the correlation degree vary according to the different calculation methods chosen, so the correlation degree between the two factors is not unique, and the degree mainly depends on the quantization method chosen and the value of the discrimination coefficient.

II. B.Application steps of gray correlation analysis

Gray correlation analysis is applicable to a wider range of scenarios while maintaining objectivity. In other words, the advantage of gray correlation analysis is that it is able to avoid the influence of subjective judgments of the scorer and reflect the importance of different influencing factors purely on the basis of numerical relationships. Compared with principal component analysis or regression analysis, gray correlation analysis can avoid the requirement of large samples or a specific distribution law. Based on this, this paper applies the gray correlation analysis method to analyze the influence factors of ecological art and landscape design collaborative innovation as follows:

(1) The correlation analysis of each influencing factor on the synergistic innovation of ecological art and landscape design. There are various factors affecting the synergistic innovation of ecological art and landscape design, some of which will have a positive impact on the synergistic innovation of ecological art and landscape design, while others are opposite. In order to be able to be more convenient in the subsequent analysis process, this process assumes that all the influences are positive, while the reverse influences will be reflected by negative values.

(2) Harmonization of influencing factor sequence scale. Since the descriptions of the influencing factors are different, for example, the ecological benefits and the artistic value are obviously not in a scale, so it is necessary to firstly de-scalarize the analyzed influencing factors.

(3) The synergistic innovation sequence of ecological art and landscape design is taken as the reference sequence, and the sequence of influencing factors is taken as the comparison sequence, and the absolute value of the difference between the two types of sequences is calculated one by one by the gray correlation of the difference sequence formula, and the absolute value series is the interpolation sequence.

(4) Sorting and screening the correlations. After calculating the correlation coefficients between the factors affecting the synergistic innovation of ecological art and landscape design through the gray correlation formula introduced in the previous section, the correlation coefficients are processed according to the correlation formula to get the correlation size and sorted according to the order from the largest to the smallest. Finally, the factors with

greater correlation are selected from the sorting results to be included in the assessment system of the main factors of synergistic innovation of ecological art and landscape design.

III. Analysis of factors affecting collaborative innovation

III. A. Data collection and analysis

III. A. 1) Design and distribution of questionnaires

(1) Questionnaire design

In this paper, nine wetland restoration art projects in the Yangtze River Delta were selected as case studies for analysis and research. The current application of this questionnaire survey is the most common Likert five-level scale assignment method, that is, the identified influencing factors are selected by the relevant people who fill in the questionnaire according to the degree of relevance or the size of the impact, and according to the options: "no correlation", "weak correlation", "weak correlation", "strong correlation", "strong correlation", "strong correlation", respectively, 1, 2, 3, 4, 5 points. The questionnaire consists of three parts. The first part is the introduction, which includes a thank you to the survey participants and an overview of the purpose and requirements of the questionnaire. The second part is the basic information of the individual, including the gender, age, highest education, occupation category and relevant working years of the respondents. The third part is the theme of the questionnaire, that is, the participants' personal views on the correlation between the influencing factors of ecological art and landscape design collaborative innovation.

(2) Distribution and recovery of the questionnaire

In order to make the study more scientific, more comprehensive and more real, this questionnaire is targeted at practitioners and experts and scholars in the landscape industry, which also ensures the validity of the questionnaire to a certain extent. The questionnaire was distributed through the network and on-site distribution, of which 300 copies were distributed through the platform of “Questionnaire Star”, and 300 copies were actually recovered, with an overall validity rate of 100%. In addition, in order to ensure the reliability of the questionnaire and its data, the reliability and structural validity of the questionnaire were tested using SPSS27.0 software.

III. A. 2) Reliability test of the questionnaire

The overall Clonbach coefficient value of the test scale was 0.928, which is greater than the theoretical reference value of 0.9, indicating that the internal consistency of the questionnaire is good, and the results of the overall reliability analysis of the formal questionnaire are shown in Table 1.

Table 1: The overall reliability analysis results of the formal questionnaire

Klonbach	Cronbach based on standardized terms	Number of items
0.928	0.928	30

III. A. 3) Structural validity test of the questionnaire

The KMO and Bartlett's sphericity test were conducted on the overall scale, and the test results showed that the overall KMO value of the questionnaire was 0.911, which was greater than 0.7. In addition, the significance level of the Bartlett's sphericity test was 0, which was smaller than the theoretical reference value of 0.05, which could indicate that the sample data obtained from the questionnaire survey conformed to the law of normal distribution, i.e., the overall reliability of the scale was good, and the results of the formal questionnaire KMO and Bartlett's sphericity test are shown in Table 2. The results of the formal questionnaire KMO and Bartlett sphericity test are shown in Table 2.

Table 2: The results of the formal questionnaire KMO and Bartlett sphericity test

KMO sampling appropriateness measurement		0.911
Bartlett sphericity test	Approximate card	4512.659
	freedom	442
	significance	0.000

III. B. Gray correlation analysis of factors affecting collaborative innovation

III. B. 1) Gray correlation calculation

(1) Determination of factors and sample data

According to the “ecological art and landscape design co-innovation influencing factors and categorization” in the initial 11 influencing factors are defined factor code: X1...... X30. The questionnaire data are divided into 9 sample groups, and the average value of each group's original score is calculated, which constitutes a sample of original data. Such as sample 1: the questionnaire survey in the serial number 1 to 11 data for the sample group, each of the impact factor score that serial number 1 to 11 of the average score. Other sample data are obtained by analogy.

(2) Determine the reference series

The reference number of each factor is the optimal value, i.e., "strong correlation", with a score of 5. In summary, the above two steps form the original data of the synergistic innovation factors of ecological art and landscape design. Synergistic innovation influence factor factor raw data shown in Table 3.

Table 3: Influencing factors - original data

Factor	Reference	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
X1	5	3.859	3.896	4.596	4.174	4.356	3.958	3.076	3.787	3.545
X2	5	4.503	4.509	4.675	4.721	4.605	4.458	4.305	4.166	4.381
X3	5	4.251	4.896	4.471	4.354	4.743	4.502	4.754	4.476	5.107
X4	5	2.364	2.517	3.002	3.081	2.898	3.628	2.909	3.181	2.812
X5	5	4.092	3.332	4.168	3.919	3.536	3.784	4.08	4.138	4.127
X6	5	3.612	2.53	4.05	3.755	4.263	3.918	3.401	4.237	3.779
X7	5	3.028	3.241	3.947	3.894	3.318	3.477	4.185	3.382	3.871
X8	5	2.947	3.442	2.959	3.892	3.683	4.362	3.41	3.144	4.345
X9	5	2.551	2.411	2.484	3.346	2.427	2.534	3.249	2.896	2.851
X10	5	4.493	3.988	4.569	4.462	4.581	4.761	4.509	4.336	4.366
X11	5	4.363	4.473	4.19	5.267	4.441	4.542	4.287	5.013	4.997

(3) Initialization of raw data: the raw data are dimensionless by applying the formula. Influence factor factors are dimensionless as shown in Table 4.

Table 4: The influencing factors are dimensionless

Factor	Reference	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
X1	1	0.732	0.773	0.834	0.872	0.823	0.761	0.637	0.75	0.767
X2	1	0.867	0.843	0.908	0.881	0.703	0.969	0.893	0.835	0.859
X3	1	0.86	0.887	0.901	0.957	0.927	0.923	0.617	0.957	0.974
X4	1	0.448	0.404	0.565	0.627	0.57	0.669	0.581	0.571	0.631
X5	1	0.73	0.809	0.786	0.896	0.748	0.756	0.793	0.721	0.795
X6	1	0.657	0.554	0.715	0.789	0.88	0.806	0.561	0.828	0.834
X7	1	0.594	0.757	0.794	0.869	0.744	0.671	0.812	0.787	0.671
X8	1	0.552	0.648	0.65	0.77	0.789	0.812	0.73	0.546	0.882
X9	1	0.451	0.455	0.508	0.549	0.596	0.493	0.671	0.586	0.517
X10	1	0.862	0.786	0.833	0.892	0.908	0.887	0.892	0.872	0.825
X11	1	0.85	0.951	0.894	0.918	0.885	0.884	0.869	0.726	0.932

(4) Calculate the absolute difference between the comparison series and the reference series using the formula. The difference series between the number test series and the comparison series is shown in Table 5.

Table 5: The difference sequence between a numerical test sequence and a comparative sequence

Factor	Reference	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
X1	0	0.165	0.18	0.168	0.124	0.12	0.151	0.388	0.284	0.193
X2	0	0.115	0.085	0.104	0.15	0.053	0.111	0.167	0.123	0.08
X3	0	0.144	0.063	0.023	0.099	0.073	0.057	0.008	0.085	0.058
X4	0	0.542	0.563	0.399	0.442	0.409	0.328	0.431	0.401	0.37
X5	0	0.237	0.231	0.175	0.153	0.227	0.226	0.248	0.201	0.225
X6	0	0.309	0.428	0.218	0.254	0.145	0.229	0.324	0.102	0.316
X7	0	0.366	0.337	0.158	0.152	0.281	0.289	0.215	0.226	0.262
X8	0	0.353	0.314	0.388	0.266	0.22	0.115	0.352	0.38	0.132
X9	0	0.507	0.554	0.443	0.403	0.433	0.508	0.32	0.381	0.444
X10	0	0.127	0.17	0.119	0.139	0.094	0.126	0.093	0.135	0.144
X11	0	0.151	0.11	0.135	0.061	0.114	0.113	0.143	0.033	0.085

(5) Calculate the correlation coefficient by applying the formula, and the differentiation coefficient of this paper is 0.5. The factor correlation coefficients are shown in Table 6.

Table 6: Factor correlation degree coefficient

Factor	Reference	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
X1	1	0.684	0.697	0.747	0.751	0.891	0.76	0.476	0.586	0.632
X2	1	0.786	0.855	0.818	0.751	0.932	0.856	0.733	0.886	0.874
X3	1	0.714	0.993	0.953	0.822	0.947	0.974	0.627	0.86	0.979
X4	1	0.423	0.357	0.47	0.45	0.539	0.55	0.483	0.485	0.606
X5	1	0.697	0.612	0.787	0.777	0.627	0.621	0.592	0.678	0.721
X6	1	0.508	0.461	0.637	0.673	0.727	0.653	0.55	0.82	0.648
X7	1	0.493	0.509	0.708	0.682	0.589	0.55	0.65	0.648	0.627
X8	1	0.514	0.524	0.51	0.615	0.685	0.695	0.583	0.546	0.751
X9	1	0.457	0.381	0.504	0.481	0.471	0.437	0.586	0.476	0.531
X10	1	0.782	0.778	0.807	0.782	0.891	0.819	0.865	0.781	0.765
X11	1	0.798	0.845	0.838	0.968	0.784	0.878	0.764	0.705	0.836

(6) Calculate the gray correlation

Apply the formula to find out the correlation degree of each influencing factor. The ranking of the correlation degree of the influencing factors of the synergistic innovation of ecological art and landscape design is shown in Table 7. From the table, ecological stability is ranked first, and its gray correlation is 0.893, indicating that the ecological stability of the landscape has an important impact on the synergistic innovation of ecological art and landscape design.

Table 7: Ranking of the correlation degree of influencing factors

Category of influencing factors	Influencing factors of collaborative innovation	Variable	Grey correlation degree	Ranking
Ecological benefit e	Enhancement of biodiversity	X1	0.709	5
	Ecological function restoration	X2	0.821	3
	Ecosystem stability	X3	0.893	1
Artistic value	Aesthetic experience	X4	0.463	11
	Creativity and uniqueness	X5	0.658	6
	Cultural expression	X6	0.599	9
Social influence	Public participation	X7	0.609	8
	The value of environmental education	X8	0.611	7
	Social and economic benefits	X9	0.472	10
Sustainability	Low maintenance cost	X10	0.784	4
	Adaptive management	X11	0.836	2

III. B. 2) Gray correlation analysis findings

Based on the gray correlation results, the influence factors of the synergistic innovation of ecological art and landscape design are divided into three levels. The first level is the high correlation factor, i.e., the correlation degree is between 0.8 and 1.0, with 3 items, ranked in the following order: ecosystem stability>adaptive management>ecological function restoration. The second tier is the medium relevance factor, i.e., the relevance is between 0.6 and 0.8, with a total of 5 items, ranked in the following order: low maintenance cost>biodiversity enhancement>creativity and uniqueness>environmental education value>public participation. The third tier is low relevance factors, i.e., the relevance is less than 0.6, with 3 items, ranked in the following order: cultural expression > socio-economic benefits > aesthetic experience.

III. C. Determination of factors influencing synergistic innovation of eco-art and landscape design

Based on the conclusion of gray correlation, the three influencing factors with low correlation were eliminated, and three high correlation and five medium correlation influencing factors were identified as the object of analysis in this paper. As a result, the final influencing factors were determined in this study, and the eco-art and landscape design synergistic innovation influencing factors are shown in Table 8.

Table 8: Influencing factors of Collaborative Innovation

Serial number	Category	Influencing factors
1	Ecological benefit e	Enhancement of biodiversity
2		Ecological function restoration
3		Ecosystem stability
4	Artistic value	Creativity and uniqueness
5	Social influence	Public participation
6		The value of environmental education
7	Sustainability	Low maintenance cost
8		Adaptive management

IV. Prediction of the effect of collaborative innovation based on BP neural network

IV. A. BP Neural Network Topology Determination

The scientific and reasonable determination of the topology of BP neural network has an important impact on the accurate prediction of the synergistic innovation of ecological art and landscape design, so the first step of establishing a prediction model is to design the topology of BP neural network.The structure of the BP neural network mainly includes the input layer, the hidden layer and the output layer, so the first step of establishing a BP neural network model is to determine the input, the hidden and the output layers of the BP neural network.

(1) Determination of input layer. The input layer is mainly to provide samples to the network model, and the correct and reasonable selection of samples will affect the accuracy of the output results.

(2) Determination of hidden layer. The hidden layer belongs to the middle layer of the BP neural network, in the process of forward and backward propagation of the BP neural network, the processing and calculation of information are carried out in the hidden layer, so the design of the hidden layer is very important. In general, the more the number of neurons in the hidden layer, the stronger the ability to solve nonlinear problems but with the increase in the number of neurons, it will also produce excessive coincidence results, resulting in a decrease in the generalization ability of the network. Therefore, an appropriate number of hidden layer neurons needs to be selected. There is no unique method to determine the number of hidden layers, if n denotes the number of neurons in the input layer, m denotes the number of neurons in the hidden layer, and l denotes the number of neurons in the output layer, there are five methods to determine the number of neurons in the hidden layer as follows:

① $m = n + l, m >= 5$.

② Let s be the number of samples, and the smallest m is: $s < \sum_{n=0}^{n-1} C_m^n$.

③ Let c be a constant between 1 and 10, and the number of implied layers is $m = \sqrt{n+m} + c$.

④ $m = \log_2 n$.

⑤ $m = \log_2 n - l$.

(3) Determination of the output layer. The output of the output layer should be the data we need to predict, the purpose of this model is to predict the synergistic innovation of ecological art and landscape design, the number of neurons in the output layer needs to be the same as the number of prediction results in this paper. Therefore, there is only one neuron in the output layer. After the above analysis, the BP neural network model in the prediction of synergistic innovation of ecological fine arts and landscape design is finally determined as 9*10*1.

IV. B. Incentive function and initialization weights, threshold determination

The transfer function f in the BP neural network model usually takes the differentiable monotonically increasing functions, including logsig(), tansig() and the linear function purelin(), etc., the hidden layer of the BP neural network usually adopts the S-type function, and the output layer adopts the linear excitation function. The S-type function is a function with a graph shape like s , which has the characteristics of nonlinearity and derivability, and the S-type function can gain control the signal to prevent the network from entering a saturated state. logsig() and tansig() are commonly used type s functions.

The methods for initializing the weights and thresholds are the randomization method and the Nguyen-Widrow method. Usually the computational results show that the randomization method does not seem to be very suitable, which leads to computational inefficiency in the face of more complex nonlinear systems. However the N-W method of initializing weights and thresholds proposed by Nguyen and Widrow achieves a significant improvement in computational efficiency. Thus the initialized weights W and the initialized threshold b are:

$$W_1 = 0.7 \times m^{1/n} \times normr(2rand(m,n) - I(m,n)) \tag{9}$$

$$W_2 = 0.7 \times l^{1/m} \times normr(2rand(l,n) - I(l,m)) \tag{10}$$

$$b_1 = 0.7 \times m^{1/n} \times (2rand(m,1) - I(m,n)) \tag{11}$$

$$b_2 = 0.7 \times l^{1/m} \times (2rand(l,l) - I(l,n)) \tag{12}$$

In Eqs. (9)-(12) n,m,l is the number of neurons in the input, hidden and output layers, respectively, $rand(m,n)$ is a uniformly distributed matrix of random numbers in m rows and n columns, and $I(m,n)$ is an all-1 matrix in m rows and n columns, which aims to ensure that the weights are distributed within the interval (-1, 1). $normr(M)$ is the normalized normalized matrix of matrix M : if $M = \begin{bmatrix} a_1 & a_2 \\ b_1 & b_2 \end{bmatrix}$, then:

$$normr(M) = \begin{bmatrix} \frac{a_1}{\sqrt{a_1^2 + a_2^2}} & \frac{a_2}{\sqrt{a_1^2 + a_2^2}} \\ \frac{b_1}{\sqrt{b_1^2 + b_2^2}} & \frac{b_1}{\sqrt{b_1^2 + b_2^2}} \end{bmatrix} \tag{13}$$

IV. C. Standardization of samples

If the samples are not processed and used directly as input sample data for BP neural network learning and training, due to the inconsistency of the data units will cause a large impact on the value domain of the transfer function, which may cause the algorithm to oscillate and do not converge, so it is necessary to standardize the samples [24]. Predictive indicators are used as the input layer sample data for the BP neural network model. Because the indicators in the predictive indicator system represent different physical quantities, they have different value ranges and types, and usually have two forms of expression: textual and numerical. In order to make the predicted results more reasonable, the data need to be normalized and standardized so that the data used for training can be as realistic as possible. Of these two types of variables, literal variables cannot be used directly as input layer variables and need to be quantized. Numerical variables need to be normalized to between [0, 1] due to inconsistent magnitudes. The data pre-processed by the above methods are easier to be trained and learned by the network. Different preprocessing methods are used according to different types of variables:

(1) Numerical variables. Numerical type variable indicators are more different from each other, need to transform the data, this paper adopts the method of standardization of deviation to deal with the data, the standardization formula is: $X_{i'} = (X_i - X_{\min}) / (X_{\max} - X_{\min})$, where $X_{\min}$ and $X_{\max}$ are the minimum and maximum values of the corresponding sequence, respectively.

(2) Text-based variables. Text-based variables need to be quantized, and this paper uses natural numbers to represent them, but these values have no practical significance and are just a form of representation instead of text. The quantified values also need to be standardized, the same method as the numerical variable processing method.

IV. D. Algorithmic flow of BP neural network

The algorithmic process of BP neural network mainly includes forward calculation of output and reverse adjustment of weights and thresholds. The basic idea is: firstly, a set of samples is input from the forward direction and its output is obtained through calculation, and then the difference between the actual output and the expected value is used in a certain way to adjust the weights and thresholds of the network in order to achieve the purpose of minimizing the difference. Finally, the above process is repeated until the difference is less than a predetermined value.

Let i,k,j be the number of neurons in the input, hidden and output layers, respectively. n,m,l be the number of neurons in the input, hidden and output layers respectively.

The algorithm flow of BP neural network model is as follows:

(1) Parameter initialization. Select the appropriate network structure and initialize the weights and thresholds.

(2) Given input $x_i (i = 1,2,...,n)$ and target output $z_j (j = 1,2,...,l)$.

(3) Calculate the hidden layer and output layer outputs, which can be calculated by the following equations, respectively:

$$y_k = f(\sum_{i=1}^{n} W_{ki}x_i - b_k), k = 1,2,\cdots,m \tag{14}$$

$$z_j = f\left(\sum_{k=1}^{m} W_{jk} f\left(\sum_{i=1}^{n} W_{ki}x_i - b_k\right) - b_j\right), j = 1,2,\cdots,l \tag{15}$$

Eqs. (14), (15) in which w_{ki}, w_{jk} is the weights of the input/implicit and implicit/output layers, b_k is the threshold of the implicit layer, b_j is the threshold of the output layer, y_k is the output of the implicit layer, and z_k is the output of the output layer.

(4) Adjust the weights and thresholds.

Calculate the error between the output layer and the implied layer:

$$e_j = z_j - o_j \tag{16}$$

In Eq. (16): z_j is the actual output of the j nd neuron in the output layer and o_j is the desired output. Calculate the error of the hidden layer neuron:

$$e_k = \sum_{j=1}^{l} e_j w_{jk} \tag{17}$$

Calculate the correction value for the output layer weights Δw_{jk}:

$$\Delta w_{jk} = lrd_j y_k \tag{18}$$

where lr is the learning rate, d_j is the local gradient, and y_k is the implied layer output. Similarly, the correction for the implied layer weights is calculated Δw_{ki}:

$$\Delta w_{ki} = lrd_k x_i \tag{19}$$

Threshold correction values $\Delta b_j, \Delta b_k$ for the output and implicit layers, respectively:

$$\Delta b_j = lre_j \tag{20}$$

$$\Delta b_k = lre_k \tag{21}$$

The weights and thresholds of the output and implicit layers are adjusted separately:

$$w_{jk}' = w_{jk} + \Delta w_{jk} \tag{22}$$

$$w_{ki}' = w_{ki} + \Delta w_{ki} \tag{23}$$

$$b_j' = b_j + \Delta b_j \tag{24}$$

$$b_k' = b_k + \Delta b_k \tag{25}$$

(5) If the error accuracy requirement is met, ie:

$$\Delta E < \varepsilon \tag{26}$$

In Eq. (26): ε is the error accuracy requirement, $0 \le \varepsilon < 1$, or if the number of cycles requirement is met, i.e:

$$t \le T^0 \tag{27}$$

Where T^o is the number of cycles required and is a large positive integer.

If the above equation is satisfied, the network training is completed.

The flowchart of the BP neural network algorithm is shown in Fig. 1.

V. Synergistic and innovative effects of eco-art and landscape design

V. A. Learning and training of BP neural network models

Based on the determination of the BP network topology, the neural network structure that constitutes 3 layers, i.e., the input layer, the intermediate layer and the output layer are 1, 10 neurons in the input layer, 15 neurons, and 1 neuron in the output layer, the learning rate is 0.000001 target error 0.0000001, and the method of adaptive adjustment of the learning rate to optimize neural networks. Using Matlab software to train the collaborative innovation prediction model of ecological art and landscape design, the main influencing factors data as the input vector of the input layer, the training samples are input into the BP neural network model for learning and training, before reaching the set number of cycles or the required target error, the weights and thresholds are determined after optimization, and the trained weights and thresholds are left in the internal data of the system, the network training process The change of error is shown in Fig. 2.

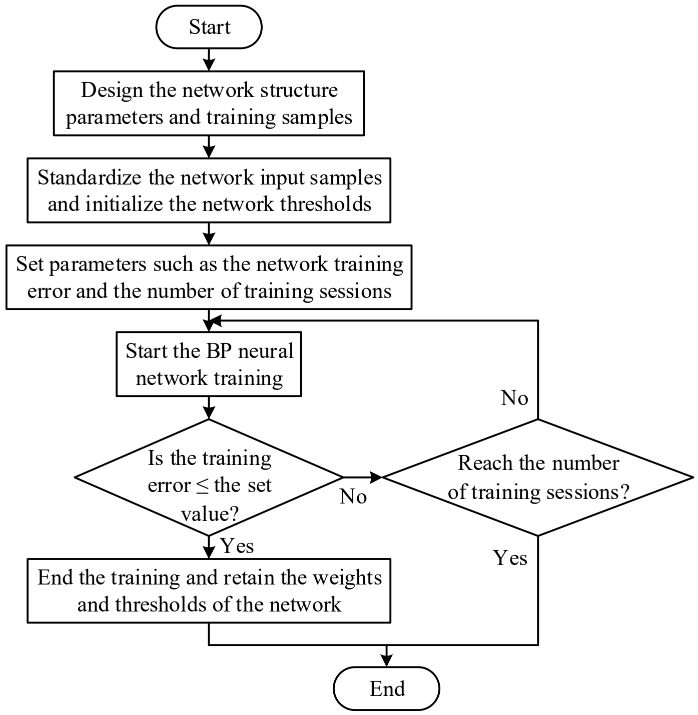

Figure 1: BP neural network algorithm flowchart

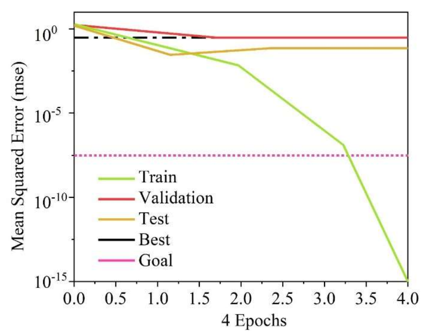

Figure 2: The error variation can be viewed

The training set, validation set, and test set regression capabilities of this network are shown in Figure 3:

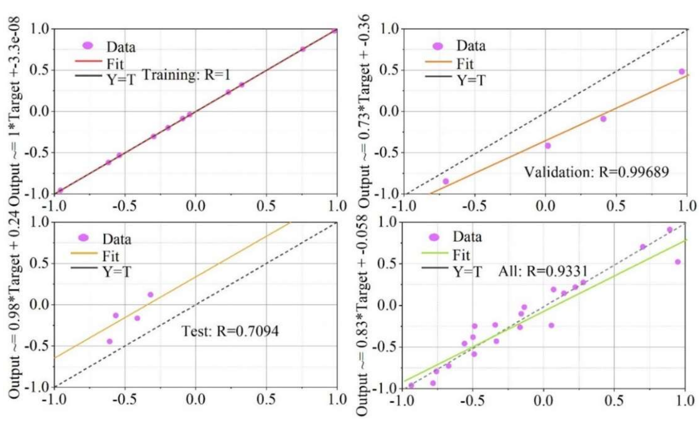

Figure 3: Visualization diagram of regression ability

The prediction results are finally obtained through the inverse normalization process, and the prediction results are shown in the table, and the average percentage error MAPE is: 10.3%, which meets the requirements of level

3 and has high accuracy. It shows that the prediction model based on this paper is suitable for the prediction of ecological art and landscape design collaborative innovation. This network test set prediction results and the actual value error table is shown in Table 9.

Table 9: The error between the predicted results of the test set and the actual values

Number	Actual value	Predicted value	Error
1	552	553	1
2	592	472	-120
3	629	473	-156
4	536	556	20
5	566	603	37

V. B. Comparison of methods and prediction results

Compare the prediction results of this paper's model with the time series analysis method, the time series model is completed by applying the expert modeler in SPSS software, and the comparative test indexes are shown in Table 10. From the data in the table, it can be calculated that the average absolute percentage error of the prediction results based on this paper's model is 3.13% lower than the prediction results of the time series analysis method, and the prediction accuracy is more advantageous than the statistical method.

It is not difficult to find that this paper's model and the traditional statistical forecasting methods, compared with this paper's model in the prediction of the strong tendency value identification ability and change prediction ability, time series analysis methods in the identification of change has a certain error and lag, this paper's prediction model prediction results compared with it is objective. Because its effect is not comparable with statistical methods, this paper's model also has a good application prospect in the simulation and ecological art and landscape design collaborative innovation prediction.

Table 10: Comparison test index

project	True value	Predicted value	
		Time series analysis	Ours
1	546	538	561
2	599	526	484
3	624	599	468
4	543	613	562
5	551	775	591
MAPE		13.65%	10.52%

VI. Summary

In order to better evaluate the synergistic innovation effect of ecological art and landscape design. The study uses gray correlation analysis to determine the synergistic innovation prediction indexes and establishes the synergistic innovation effect prediction model of BP neural network. The conclusions drawn from the study are:

Based on the gray correlation results, the study obtained three high correlation factors, namely, ecosystem stability, adaptive management and ecological function restoration, and five medium correlation factors, namely, low maintenance cost, biodiversity enhancement, creativity and uniqueness, environmental education value and public participation. It can be concluded that the protection and restoration of ecosystems are of great significance to the synergistic innovation of eco-art and landscape design.

The average absolute percentage error of the prediction results based on the model of this paper is 3.13% lower than the prediction results of the time series analysis method, from which it can be concluded that the model of this paper has a good application in the prediction of synergistic innovation of ecological art and landscape design.

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