SUSTAINABLE DEVELOPMENT OF VOCAL MUSIC ECOLOGY IN A DIGITAL ECOLOGICAL ENVIRONMENT

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ABSTRACT

The phenomenon of noise interference during vocal transmission can lead to the problem of poor vocal transmission quality. This paper proposes a study on the sustainability of vocal ecology in a digital ecological environment. First, the matching tracking algorithm can extract the time-frequency characteristics of the effective signal, attenuate the interference of noise, and improve the propagation quality. A sustainable development GA-BP network model is established, and the adjustment amount of each weighting coefficient is obtained according to the gradient algorithm and using the inertia adjustment strategy. The coordination is regulated through feedback control strategies to ultimately achieve ecological sustainability of vocal music. The analysis results show that the average relative error of the simulation prediction of the sustainable development GA-BP network model is 3.54%, the maximum relative error is 8.11%, and the average relative error is within 5% of 70%. It has significant superiority and high efficiency in comparison with the prediction degree of the traditional model.

KEYWORDS

Digital ecology; Vocal ecology; Sustainability; Time-frequency characteristics; GA-BP model

INDEX

https://doi.org/10.17993/3ctic.2023.122.324-340

1. INTRODUCTION

At this stage, traditional vocal music has faced an increasing crisis of survival, and many of these varieties have reached a situation where there is no one to succeed them and they are on the verge of being lost [1]. Therefore, the question of how to develop the economy while preserving this cultural heritage from its impact is becoming more and more of a challenge for the vocal community. Whether the traditional vocal music is preserved in a "museum style" or in a dynamic process of "moving without changing shape", there are various ways to preserve it [2-4]. However, the fundamental reason for the current crisis of traditional vocal music lies in the changing ecological environment and the "imbalance" in the development of Chinese vocal music culture [5-7]. Therefore, the conservation and development of traditional vocal music must not deviate from traditional vocal music and its related ecosystem, and must not deviate from the direction of development recognized by contemporary human society, which is the path of "sustainable development" [8-11].

Ecosystem was originally a natural science concept for studying the relationship between organisms and their living environment, which was later used by other humanities and social science scholars [12-15]. The so-called ecosystem of traditional vocal music is the state of existence of traditional vocal music and its relationship with the surrounding cultural vein [16-19]. According to this definition, the author not only focuses on traditional vocal music in this paper, but also places it in a broader context to examine the mechanism of interaction, interdependence, and interconstraint between it and the natural, economic, and cultural environments at different stages of human civilization's development [20-22].

The concept of sustainable development means that not only can the needs of modern people be met, but more importantly its ability to allow future generations to take a more reasonable interest in it and give full play to its utility [23]. It is an inevitable trend for vocal ecology to take the path of sustainable development [24]. Many people have different views on it, regardless of any viewpoint, its final purpose is that vocal music can take a sustainable path. So that vocal music can endure in the world of music and not be replaced or disappear [25].

The literature [26] found that the Birmingham School transformed popular vocal music, film, television, advertising, and other forms of popular culture from a condemned "other" to an "I" worthy of understanding and study. As a form of text, vocal music conceals different ideological positions behind its text. To achieve a "common and beneficial" vocal cultural ecology, it is necessary to construct a vocal cultural ecology model by taking people's intervention and two-way dialogue as the basic path. In the literature [27], it is argued that the demand for education has greatly increased with the popularization of Internet informatization, and so has the teaching of vocal music in universities. Nowadays, digitalization has gradually become a main trend on university campuses, and it is a big trend not only in China but even in the international arena. Thus, university vocal teaching should make full use of the digital campus environment and take advantage of this condition of exogenous factors, and

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university vocal teaching can also enter a new mode and make continuous progress. Therefore, teachers in university vocal music teaching should first change their teaching concepts and develop their information literacy skills, so that they can make university vocal music education compatible with the digital campus environment. The article mainly analyzes how university vocal teachers should change their concepts and correctly use digital thinking to reform university vocal music. Then the teaching concept is updated, information literacy is cultivated, and the reform of the university vocal music teaching mode is actively carried out. The teacher's successful change of teaching concept is the full use of the digital campus environment, which is conducive to the reform of the university vocal music teaching mode. The literature [28] argues that folk vocal music is a very important type of vocal music at present, and it is developing rapidly all over the world. Folk vocal music is a kind of embodiment of national culture, and its good development and dissemination is the development and dissemination of national culture. The new media environment provides a better platform for propaganda and development, and through the corresponding technology to achieve better results, so that the national culture can also be well reflected. According to literature [29], the emergence of Massive Open Online Course (MOOC), a large-scale online course, has injected new vitality and vigor into global education reform. Universities in various countries have started a boom in building MOOC platforms, and vocal music teaching in universities has also joined the tide of reform. The literature [30] shows that the emergence of new media has had a profound impact on people, and vocal performance skills development is also deeply affected by the new media environment. Vocal performance also needs to adapt to the characteristics of the new media environment and meet the requirements of the new media environment. Compared with the traditional training method, the way to cultivate vocal performance skills in the new media environment has undergone a big change. The focus should be on innovation from stage design, new musical instruments, and the performers themselves, giving full play to the role of media communication to enhance the vocal performance skills of the performers. To help performers better express their vocal works and more fully embody the thoughts and emotions contained in the works.

To sum up, this paper further develops this issue based on the previous research. This paper proposes a study on the sustainable development of vocal ecology in the digital ecological environment. Unlike the above studies, this paper explores the sustainable development of vocal ecology from the perspective of a digital ecological environment. Through MP time-frequency feature extraction, the interference of noise is reduced to improve the quality of vocal music when it is transmitted. Then a sustainable GA-BP network model is constructed, and the coordination degree is adjusted by using a feedback control strategy. Finally, the sustainable development of vocal music ecology is realized.

2. DIGITAL ECOSYSTEM

At this stage, cloud storage, cloud computing technology, mobile intelligent terminals, and other concepts are slowly blowing a new wave [31]. Social development operation timeout takes mobile data network as the key information period, and all kinds of Internet media are diverse. The integration and combination of a lot of information promote the rapid development of all walks of life. Therefore, it is particularly critical to the ability of data collection and sorting. From the perspective of communication, the original instrumental music is easier to spread than the simple method of "oral and heart-to-heart teaching" or the initial Internet media such as turntables, tapes, and short videos of television and radio. Today, the communication methods and regions of Internet media are more common, and the coordination ability of communication methods is more diversified. It has added a new opportunity to the spread and development trend of music art, thus adding new challenges.

The deep integration of digital technology and digital means with ecological environmental protection will help build a wise and efficient information system for ecological environmental management and provide strong support for improving the modernization of environmental governance. The party group meeting of the Ministry of Ecology and Environment also pointed out that the ecological and environmental system should effectively improve the ability to think and professional quality of the digital economy, and digitally help promote the modernization of the ecological and environmental governance system and governance capacity [32].

Vocal music communication under the protection of data and information ecological environment shows many new characteristics and realizes the change of communication methods from simplification to diversification. Traditionally, the production and transmission of vocal music is unilateral, and the transmission process is a simple, top-down linear process. Under the protection of data information ecological environment, vocal music communication methods will have great changes. No matter the founder of vocal music, the lecturer of management mode, or the audience, they can become part of the vocal music communication process. The whole process is closely connected and overlapped with each other. The communication and connection between these three subjects are immediately fair, which enriches the vocal communication methods [33]. Therefore, to complete the innovative development of vocal communication, we should first create a new core value of communication. Instead of sticking to traditional communication methods, we should think about the key points in the communication process and combine a new communication method. Under the complex network, we attach great importance to the demand of vocal music itself for creative quality. From the perspective of the audience, strive to write vocal classics close to life and full of positive energy, flexibly use Internet technology and network resources to communicate and exchange software development technology, constantly innovate communication concepts, and establish a sense of design and development of scientific and technological innovation.

https://doi.org/10.17993/3ctic.2023.122.324-340

3. VOCAL ECOLOGICAL SUSTAINABILITY STRATEGY

3.1. MP TIME-FREQUENCY FEATURE EXTRACTION

Ecological environmental vocal signals are complex signals, consisting of multiple sounds and noises, and it is a difficult task to reduce noise interference and ensure vocal quality when propagating these sounds [34]. The key is how to extract features with better noise immunity. Frequency domain features are commonly used as Mel frequency cepstrum coefficients, while time-frequency domain representations are commonly used as short-time Fourier transform and wavelet transform. When extracting time-frequency features, the signal is decomposed into several waveforms that best match this signal, which are called time-frequency atoms. MP is a decomposition that selects the most suitable signal structure on a redundant dictionary of Gabor atoms to obtain a flexible, intuitive, and judgmental feature set. Therefore, the MP algorithm is proposed to be used to obtain effective time-frequency features.

As shown in Figure 1, the first step of the classification system is the front-end processing, which includes pre-processing and feature extraction. In the feature extraction stage, we extract the MFCC parameters, and MP time-frequency features.

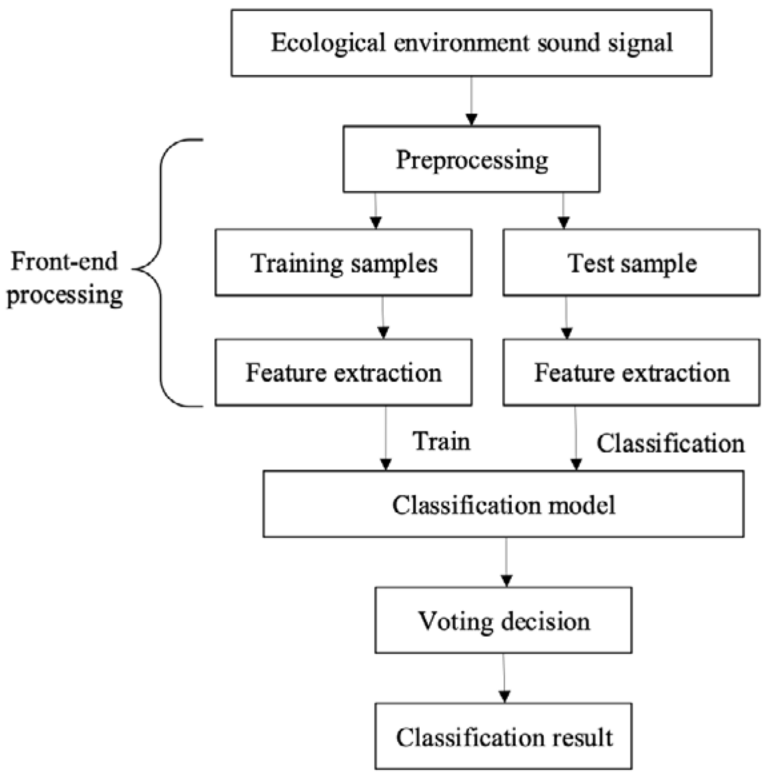

Figure 1. Classification system diagram of vocal ecology

All sound files were sampled using a sampling frequency of 11025Hz, 16 bits per sample, and polyphonic to monophonic conversion. Finally, all sound files were organized into two parts, one for training and the other for testing. The duration of

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each type of sound file used for training was 30 seconds, while each type of sound file used for testing had 20 files, each with a duration of 3 seconds.

The MFCC was analyzed from the perspective of the human ear's nonlinear psychological perception of frequency height, and a nonlinear Mel frequency scale was used to simulate the auditory system of the human ear. The specific steps for calculating MFCC parameters are as follows.

1. (1) Divide the ecological audio signal into a series of consecutive frames, here with Hanning windowed framing, each frame containing $N = 1024$ samples, adjacent frames with 512 samples overlap. The discrete power spectrum $x(n)$ is obtained by taking the square of the mode after the fast Fourier transform of each frame $x(n)$ after windowing.

2. (2) Design a filter set $H_m(n)$, $m = 0,1,\cdots, M-1, n = 0,1,\cdots N/2-1$ consisting of overlapping triangular bands, where $M = 36$, N is the number of samples of a frame, and these bands are nearly uniformly distributed on the Mel axis. Calculate the power value P_m, $m = 0,1,\cdots, M-1$ after passing through M triangular filter $H_m(n)$.

3. (3) Calculate the natural logarithm of P_m, and then further do the discrete cosine transform (DCT) to obtain a set of MFCC parameters $Mfcc_m$, $m = 0,1,\cdots, K-1$. The DC component $Mfcc_0$ is discarded, and the latter $K-1$ coefficients are taken as MFCC parameters. In this study, the K value is taken as 17, i.e., only 16 MFCC coefficients are extracted from each frame.

The basic idea of MP is based on the decomposability and reconstruction of the signal by adaptively searching for time-frequency atoms that can match the local features of the signal in an overcomplete library, and finally representing the signal as a linear combination of time-frequency atoms [35]. This algorithm provides a sparse linear expansion of the waveform to decompose the signal over an overcomplete function dictionary.

The following describes the main steps of the MP algorithm.

Need to make the dictionary D become a waveform with parameters φ_γ, denoted as follows:

$$D = \left\{ \varphi_\gamma : \gamma \in \Gamma \right\} \tag{1}$$

Here Γ as a set of parameters and φ_γ as elements. The information decomposition of a signal s can be expressed as:

$$s = \sum_{i=1}^{m} \alpha_{\gamma_i} \varphi_{\gamma_i} + R^{(m)} \tag{2}$$

https://doi.org/10.17993/3ctic.2023.122.324-340

Here $R^{(m)}$ is the remainder. For a given s, m and D, get minimized $\gamma_i(i = 1,2,\cdots,m)$, $\alpha_{\gamma i}(i = 1,2,\cdots,m)$ that minimizes $R^{(m)}$.

The atom φ_{γ_0} As the first element, the details are as follows:

$$\left| < s, \varphi_{\gamma_0} > \right| \text{Ö} \left| < s, \varphi_{\gamma} > \right| \quad \forall \gamma \in \Gamma \tag{3}$$

The first operation extracts the atoms φ_{γ_0} from s, obtaining the remaining $R^{(0)}$. The formula is obtained as:

$$s^{(k)} = s^{(k-1)} + \alpha_k \varphi_{\gamma_k} \tag{4}$$

Where $\alpha_k = R^{(k-1)}$, $\varphi_{\gamma_k} >$ and $R^{(k)} = s - s^{(k)}$. The relationship between the approximate decomposition and the residual $R = R^{(m)}$ of the actual signal after m iterative operations is shown in Equation (2).

Since the decomposition based on Gabor time-frequency domain atoms is more flexible. Therefore, we construct the dictionary using the Gabor function, which is a sinusoidally modulated Gaussian function, and the discrete Gabor time-frequency atoms are represented as follows:

$$g_{s,u,\omega,\theta}(n) = \frac{K_{s,u,\omega,\theta}}{\sqrt{s}} e^{-\pi(n-u)2/s^2} \cos[2\pi\omega(n-u)+\theta] \tag{5}$$

Where $s \in \in^{+}$, u, $\omega \in$, $\theta \in [0,2\pi]$ and $K_{s,u,\omega,\theta}$ are normalization factors, so $\| g_{s,u,\omega,\theta} \|^2 = 1$, $\gamma = (s, u, \omega, \theta)$ is used to denote the parameters of the Ga- bor function. The atomic parameters of the Gabor dictionary in the MP algorithm are selected from the binary integer sequence. The proportion s corresponds to the width of the atom (which varies with time) and is obtained from the binary sequence $s = 2^p$, $1\tilde{\mathbf{N}}p\tilde{\mathbf{N}}m$ and the size of the atom is $N = 2^m$.

The framing process for extracting MP time-frequency features is the same as for extracting MF-CCs earlier, with 1024 samples per frame and 50% overlap.

3.2. GA-BP NETWORK MODELING

BP neural network can not only complete the input and output of discrete system projection but also complete self-learning and simple construction. However, the BP neural network training speed is relatively slow, so we must use an optimization algorithm to improve[36].

Genetic algorithm (GA) is an arbitrary global search and optimization method that follows the theory of natural selection and species evolution and develops rapidly [36]. By improving the BP neural network (GA-BP) according to the genetic algorithm, we can better get the initial weight value and threshold value of the neural network, prevent network training from falling into the local minimum value, and strengthen the convergence speed. The GA-BP network model of sustainable development is shown in Figure 2 below.

The network has high robustness and fault tolerance and can solve the impact of noise interference. Parameters and the size of the model are the key factors affecting the training speed of the network model. The network stores its learned parameters or weights in the main memory. Generally, the less weight the model has, the faster it will run. Select the feedback Hopfield network structure, as shown in Figure 2, including an input layer, an implicit layer, and an output layer. Of which:

1. Input layer neurons: demand influencing factors and supply influencing factors, a total of N (the same influencing factor is counted as one), neurons are noted as $\{Z_1, Z_2, \cdots, Z_N\}$;
2. Output layer neurons: the actual representation of coordination, only one;
3. Implied layer neurons: the number of neurons is M, neurons are recorded as $\{H_1, H_2, \cdots, H_M\}$.

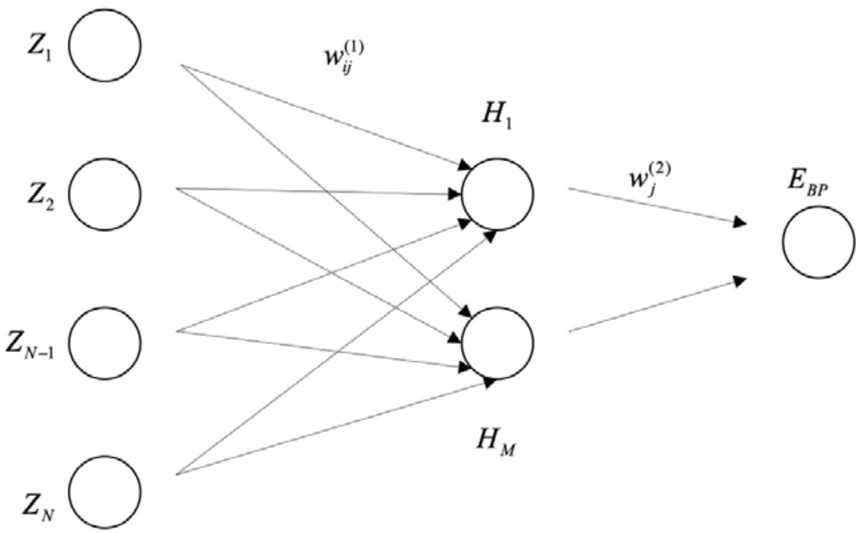


Figure 2. Sustainable development GA-BP network model

Let the connection weight coefficient from the input layer to the hidden layer be $W_{ij}^{(1)}(i = 1,2,\cdots, N; j = 1,2,\cdots, M)$. Let the node outputs of the hidden layer and the output layer of the $1(1 = 1,2,\cdots, n)$ training sample $(z_{11}, z_{12}, \cdots, z_{1n})$ be $h_{ij}(j = 1,2,\cdots, M)$ and v_1 respectively:

$$h_{1j} = f\left(\sum_{i=1}^{N} w_{ij}^{(1)} z_{1i}\right) \tag{6}$$

$$v_1 = f\left(\sum_{j=1}^{M} w_j^{(2)} h_{1i}\right) \tag{7}$$

https://doi.org/10.17993/3ctic.2023.122.324-340

Where f is the Sigmoid function $f(x) = \left(1 + e^{-x}\right)^{-1}$.

Let the ideal output of the 1st training sample be θ_1, which is defined as:

$$\theta_1 = \begin{cases} 1, \rho \text{O} \rho^* \\ 0, \text{ Other} \end{cases} \tag{8}$$

Where ρ^* describes the coordination threshold. Then the total error of all sample outputs is defined as:

$$E_{BP} = \sum_{i=1}^{n} \left(v_1 - \theta_1\right)^2 \tag{9}$$

For the initial values of the randomly generated weight coefficients, there must be an error between the actual output and the desired output. In this paper, the error back propagation GA-BP algorithm is used to gradually reduce the total error by continuously learning the training samples and adjusting the weight coefficients, and the network learning process ends when the error reaches a specified level.

First, we calculate the output error squared and the partial derivatives concerning the weight coefficients separately:

$$\begin{cases} \frac{\partial E_{BP}}{\partial W_j^{(2)}} = \sum_{l=1}^{n} \frac{\partial E_{BP}}{\partial v_1} \frac{\partial v_1}{\partial W_j^{(2)}} \\ \frac{\partial E_{BP}}{\partial W_j^{(1)}} = \sum_{l=1}^{n} \frac{\partial E_{BP}}{\partial v_1} \frac{\partial v_1}{\partial h_{ij}} \frac{\partial h_{ij}}{\partial W_{ij}^{(1)}} \end{cases} \tag{10}$$

Secondly, according to the gradient algorithm and using the inertia adjustment strategy, the adjustment amount of each weight coefficient is obtained:

$$\begin{cases} \Delta W_j^{(2)}(t+1) = \varepsilon\left(-\frac{\partial E_{BP}}{\partial W_j^{(2)}}\right) + \delta \Delta W_j^{(2)}(t) \\ \Delta W_{ij}^{(1)}(t+1) = \varepsilon\left(-\frac{\partial E_{BP}}{\partial W_{ij}^{(1)}}\right) + \delta \Delta W_{ij}^{(1)}(t) \end{cases} \tag{11}$$

Where ε represents the training pace and δ represents the inertia coefficient. Finally, the equations are updated according to the coefficients entitled by equations (10) and (11), and the expressions are obtained as follows:

$$\begin{cases} W_j^{(2)}(t+1) = W_j^{(2)}(t) + \Delta W_j^{(2)}(t+1) \\ W_{ij}^{(1)}(t+1) = W_{ij}^{(1)}(s) + \Delta W_{ij}^{(1)}(t+1) \end{cases} \tag{12}$$

This paper designs a feedback control algorithm for the demand-supply influence factors. The adjustment quantity is determined as follows.

https://doi.org/10.17993/3ctic.2023.122.324-340

Let the sample state $(z_1, z_1, \cdots, z_N)$, whose components are the demand or supply influencing factors, if the coordination degree ρ of the sample does not reach the predetermined threshold $\rho*$, take the control strategy as follows: adjust z_k to $z_k + \Delta z_k$, where Δz_k is the adjustment amount of the response, specifically determined according to the following formula:

$$\begin{cases} f\left(\sum_{j=1}^{M} W_j^{(2)} h_j \right) \ddot{O} \rho^* \\ h_j = f\left(W_{kj}^{(1)} \Delta z_k + \sum_{i=1}^{N} W_{ij}^{(1)} z_i \right), j = 1, 2, \cdots, M \end{cases} \tag{13}$$

The value of the adjustment Δz_k of the state component z_k can be obtained by solving equation (13) backward according to Newton's iterative method.

4. ANALYSIS AND RESULTS

The contradiction between man and nature, development, and limitation is gradually recognized and has now become a hot spot for research. The concept of sustainable development is proposed in such a context. China's vocal ecology is gradually developing into one of the pillar industries of the national economy, so it is of great strategic importance to study the sustainable development of vocal ecology.

This paper takes SPSS software as the platform and uses a data-reduction module and neural networks module to simulate pca2rbfnn. The data from 324 months from January 1995 to December 2021 of the input layer index are used as the sample set, the data from 300 months from 1995 to 2021 are used as the training set, and the data from 24 months from 2020 to 2021 are used as the test samples for the test of the results. GA-BP neural network and BP neural network are used to predict respectively, and the root mean square error (MSE) and average relative error (MAPE) are compared and analyzed. To verify the efficiency of the vocal ecology sustainable development model established in this paper.

$$MAPE = \sum_{n=1}^{N} \frac{\left| \frac{y_n - \overline{y_n}}{y_n} \right|}{N} \tag{14}$$

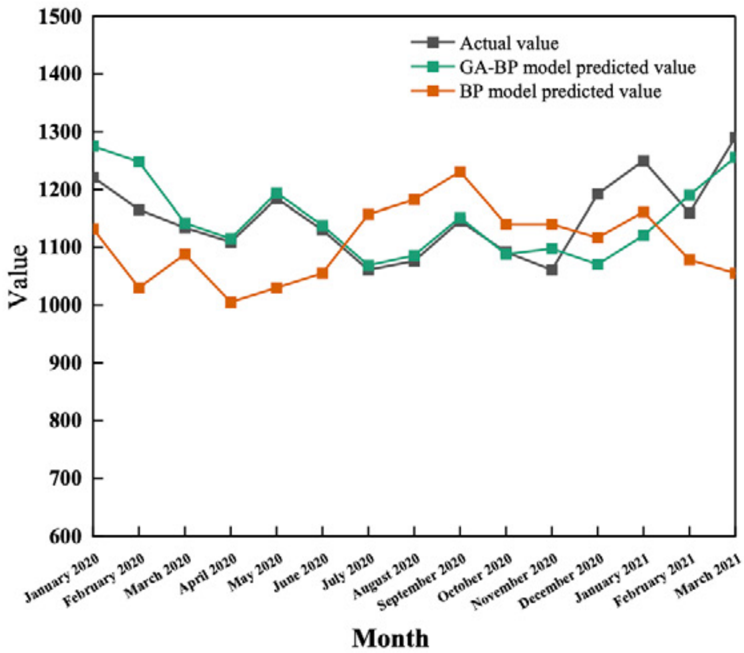
$$MSE = \sqrt{\frac{1}{N} \sum_{n=1}^{N} \left(y_n - \overline{y_n} \right)^2} \tag{15}$$

Where y_n is the true value, $\overline{y_n}$ is the simulation prediction value, and $n = 1,2,\cdots, N$ is the number of test samples, which is 24.

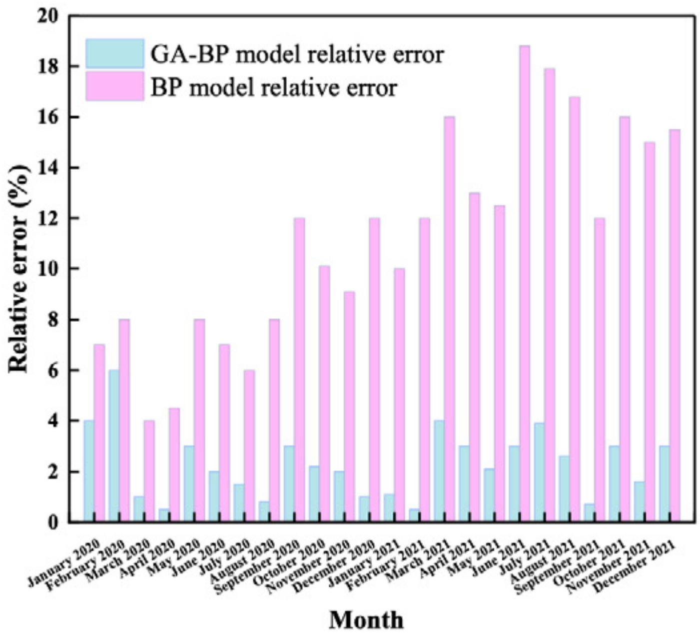
In neural network training, the overall goal of Internet training is 0.001%, and the learning rate is 0.1. When the original weight value of a neural network is optimized,

https://doi.org/10.17993/3ctic.2023.122.324-340

the population value is 100, the number of genetic iterations is 300, the value of crossover probability is 0.7, and the probability of gene variation is 0.005. The simulation training is carried out according to the neural network. The estimated conclusions from 2020 to 2021 are shown in Figure 3 below. The simulation error of the two modes is calculated according to table (14) and style (15), and the conclusion is shown in Table 1.



(a) Actual and simulated predicted values



(b) Forecast error percentage

Figure 3. Comparison of prediction values of different models from 2020-2021

https://doi.org/10.17993/3ctic.2023.122.324-340

It can be seen that the built model compared to the traditional model from 2020 to 2021 can describe the general development trend of vocal music development trend.

The average relative error of simulation prediction of the GA-BP neural network model is 3.54%, the larger relative error is 8.11%, and the average relative error is 70% within 5%. The simulation and prediction effect of the GA-BP neural network is very good, and it can better grasp the transformation of vocal music development trends. The average relative error of the BP neural network is 10.16%, and the larger relative error is 14.50%. The MSE of the two neural network models is very large.

Table 1. Simulation performance comparison of neural network models

Method	GA-BP	
Mean square error	2591.98	19150.28
Average relative error (%)	3.54	10.16
Maximum relative error (%)	8.22	14.50
Convergence accuracy	5.96E+04	3.73E+03
Iterations	195	285

According to the construction performance of neural networks, and then the prediction and analysis accuracy of the Internet can be improved. By further improving the simulation performance, it can be found that the convergence accuracy and iteration times of the GA-BP neural network entity model are significantly better than those of the BP neural network entity model. In other words, the GA-BP neural network has a faster convergence rate and convergence accuracy than the traditional BP neural network, which shows that using an evolutionary algorithm to improve the BP neural network is effective. The deviation, convergence rate, and accuracy of prediction and analysis are better than the BP neural network, which is normative for vocal music dissemination, and can be used as the basis for distinguishing the development trend of vocal music green ecology.

As a key form of expression in the construction of spiritual civilization, music art has been increasingly emphasized by everyone. Under the protection of data ecological environment, collect and sort out different vocal music network resources according to data statistical analysis. Reasonable and effective dissemination of vocal plastic arts, the audience can get a variety of relatively satisfactory information content through simple retrieval, and provide convenient service items for everyone more purposefully and effectively. The dissemination theme is clear and perfect, giving the audience a multi-directional and integrated visual experience. At the same time, vocal music transmission saves a lot of time and network resources. Vocal music network resources can be continuously reused many times, further improving the dissemination efficiency.

5. DISCUSSION

The vocal plastic arts of some groups are shared by others through the publication of social software, which promotes the transmission of such vocal music network resources for more people to appreciate. We should attach great importance to the interactive communication of all parts of the whole process of communication, identify problems as soon as possible, and understand the audience's feedback. In the indoor space of the Internet, strict supervision is also needed to maintain the Internet discipline of physical and mental health and harmony. Give warning and corresponding punishment for plagiarism. At the same time, we should focus on purifying the network environment, sort out unhealthy and depressed vocal music works, and give us active vocal music network resources.

6. CONCLUSION

In this paper, the sustainable development of vocal music ecology is studied from the perspective of a digital ecological environment. The vocal music sustainability model of the GA-BP network is constructed for prediction and comparative analysis, and the results show that.

1. A total of 324 months of data from 1995-2021 was used as the sample. The network training target is 0.001% and the learning rate is 0.1; in the process of optimizing the initial weights of the neural network by genetic algorithm, the number of populations is 100, the number of genetic iterations is 300, the value of crossover probability is 0.7 and the probability of variation is 0.005.

2. The vocal music sustainability development model of the GA-BP network was constructed and analyzed using monthly data, and the average relative error of simulation prediction was 3.54%. It indicates that the multi-input GA-BP neural network model based on monthly data can accurately predict the changing trend of vocal music ecological development, which has a certain guiding significance for the future development path of vocal music.

3. The maximum relative error of GA-BP neural network model simulation prediction is 8.22%, and the average relative error within 5% accounts for 70%, which indicates that the simulation prediction of GA-BP neural network is better and can reveal the trend change of vocal music development better.

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