

## Research Article

# Construction and Research of Guqin Sound Synthesis and Plucking Big Data Simulation Model Based on Computer Synthesis Technology

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Received 10 September 2021; Revised 19 October 2021; Accepted 22 October 2021; Published 24 March 2022

Academic Editor: Gengxin Sun

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The application and economic efficiency evaluation mode of traditional composition in the field of modern music cannot meet the needs of various types of music in China, especially Guqin music. Based on this, this paper studies the big data simulation model of Guqin sound synthesis and plucking based on computer composition technology. The computer composition technology uses the discrete dynamic modeling technology of complex system to complete the computer simulation of Guqin sound through the analysis of the correlation between Guqin music data and realizes the storage and analysis of the generated Guqin sound data. In addition, the technology can analyze the data information of composition mode in the piano sound plucking simulation model with the classical Guqin music data stored in the cloud system over the years and then feed it back to relevant professionals for verification. The experimental results show that the Guqin sound simulation model can efficiently compare and analyze the melody and other data of classical Guqin sound with the simulated Guqin sound and can realize secondary data mining. This paper studies the application of computer composition method based on discrete dynamic modeling technology in Guqin sound simulation, which has certain reference significance for improving the cloud data in China's modern music field and the intelligent construction of Guqin sound data cloud storage system.

## 1. Introduction

According to relevant data, the chord simulation of Guqin sound and the analysis mode of vocal music data in China are mainly based on the traditional “data classification” single piano sound simulation, supplemented by the “data clustering” vocal music analysis mode [1]. Since the beginning of the 21st century, the rapid development of various information technologies in China has triggered changes in the creation and correlation mode of various piano sound simulation technologies in the field of modern music. With the emergence of big data analysis model, it provides an opportunity for large-scale intelligent Guqin sound simulation based on discrete dynamic modeling technology [2]. Therefore, the discretization of vocal music simulation has become an important feature of vocal music simulation technology in analyzing the sound of Guqin [3]. At present,

although the existing piano sound simulation technology provides a large number of computer simulation vocal music schemes, in the simulation process involving melody and timbre, it is difficult to select a targeted piano sound simulation model according to the evaluation requirements of song characteristics and the requirements of song listeners, so as to achieve the optimal simulation effect [4]. Under this background, combined with the application status of computer technology in the field of piano sound simulation, this paper proposes a computer Guqin sound chord simulation model based on discrete dynamic modeling technology [5].

Aiming at the problems of low simulation rate and low accuracy of piano sound simulated by traditional piano sound simulation technology in the face of different composition methods, this paper studies the intelligent chord simulation model of computer composition technology in

modern Guqin sound simulation, which is mainly divided into three parts. The first part introduces the research status of vocal music simulation methods in modern music field and cloud data verification of vocal music simulation information. In the second part, the intelligent simulation model of Guqin sound based on computer composition technology is constructed. The composition technology uses discrete dynamic modeling technology to construct the cloud data system of piano sound simulation data. The third part tests the simulation model of computer intelligent simulation Guqin sound and related cloud data system, analyzes the results and draws a conclusion.

Compared with the traditional piano sound simulation model with nontargeted simulation technology as the main simulation technology, the innovation of this paper is to build a new computer composition method with the help of discrete dynamic modeling technology, and use this technology to build a new Guqin sound simulation model and cloud data system. The model can not only realize different kinds of piano sound simulation through different composition methods, but also classify and upload these simulation data to the cloud system and store them. At the same time, it can make full use of the vocal data of classical Guqin music and the vocal data of piano sound obtained by simulation for comparative analysis, and then realize secondary data mining through feedback, so as to realize the closed-loop process of intelligent simulation of Guqin sound by computer according to different composition methods. On the other hand, the double coupling factor is used to quantitatively describe the data matching degree between the comparison column and the reference column and the coincidence degree of the expected indicators, and the quantitative indicators are used to complete the Guqin song scoring indicators for different audiences, which can efficiently carry out customized analysis on the data indicators affecting the satisfaction of different audiences.

## 2. Related Work

At present, there are some problems in the quality evaluation and audience scoring standard of computer composition in piano sound simulation [6], especially in the data utilization of vocal music simulation for different simulation methods [7]. Luo et al. found that most computer vocal music simulation technologies still adopt the single simulation idea of sound, while ignoring the impact of indicators such as sound color, melody and audience satisfaction effect on the simulation [8]. According to the characteristics of Guqin music in different regions, it is proposed to pay attention to the development of targeted cross regional Guqin music simulation creation [9], strengthen the development and construction of piano sound simulation in different regions, and improve the cognition and sharing of modern piano sound simulation data [10]. Gabrielli et al. have carefully divided various types of Guqin vocal music for computer simulation according to different computer vocal music simulation technologies and composition methods [11]. Sabatini et al. combined the value evaluation model and game theory [12], Dobson et al. proposed a score oriented

piano music simulation system for different audiences' preferences for different audiences, and verified the effectiveness of the model through the pilot practice [13]. Based on the theory of collaboration, Li et al. proposed an innovative review method of piano sound and chord simulation models for different composition methods [14]. Through the satisfaction research and analysis of the piano sound simulated by the same simulation technology through different composition technologies, it is found that this method can realize the targeted selection of composition technology, It effectively improves the satisfaction of simulated piano sound [15]. In order to improve the simulation efficiency of the simulation model, Rohfritsch A and other scholars proposed a new "end-to-end" new targeted Guqin sound simulation system [16], and verified the effectiveness of the system through practice, which is suitable for rapid simulation analysis for different types of data. Some different types of simulation data are selected for simulation to verify the effectiveness of the system [17]. Later, the deformed super factor sequence is used to scramble and reset the internal vocal structure of the simulated piano sound data. The results show that the innovative Guqin piano sound simulation system has good data analysis effect and simulation speed, and can be used for rapid and targeted simulation of different types of data [18]. Zhang et al. proposed a new adaptive neural network piano sound simulation algorithm. The results show that the algorithm has the advantages of high stability and simple operation. At the theoretical level, it can quickly analyze the characteristics of different melodies and frequencies of piano sound [19]. In order to verify the operability in practice, Peters et al. put forward the sharing and matching strategy of built-in stored data based on various types of simulation technologies. The results show that this strategy can effectively reduce the frequency of errors in the simulation model according to different simulation requirements and improve the accuracy of the simulation model [20]. In order to improve the calculation efficiency of the model for the redundant data generated by the composition method and evaluation system, Yu et al. proposed the Fourier function algorithm. The results show that the algorithm can effectively improve the operation efficiency of the model for the redundant data and the overall simulation speed [21]. In order to solve the problem of slow running speed of the model when analyzing the input piano sound data, Zhou et al. put forward a model optimization scheme based on clustering algorithm and particle swarm optimization algorithm. Experiments show that this scheme can greatly accelerate the analysis ability and data reading ability of the model for piano sound [22].

To sum up, it can be seen that the current piano sound simulation models based on nontargeted simulation technology have not established corresponding vocal melody analysis system and data storage system, and basically do not involve computer piano sound simulation technology based on dynamic modeling technology and related cloud data storage model [23]. On the other hand, although China has done a lot of research on the simulation of piano sound in different composition methods, there is a lack of relevant research results in providing intelligent simulation schemes.

Therefore, it is of great significance to carry out the analysis of big data model of plucked instruments for the synthesis of Guqin sounds based on computer composition technology.

### 3. Methodology

**3.1. Application of Computer Composition Technology in Big Data Simulation of Guqin and Plucked String Instruments.** In the research on the application of computer technology in modern piano vocal music simulation, it is inseparable from data analysis and modeling technology. There are many common data analysis and modeling technologies, such as discrete dynamic modeling technology (DEA). This method is a new field of cross research of operations research, computer science and simulation [24]. The piano sound simulation model is a linear programming model, which is expressed as the ratio of simulation output to input. This method attempts to maximize the simulation rate of the simulation unit by comparing the efficiency of a specific unit with the performance of a group of similar units that provide the same simulation effect [25]. In this process, some units that obtain 100% simulation rate are called relatively effective simulation units, while other units with simulation score less than 100% are called invalid simulation units. It is a quantitative analysis method to evaluate the relative effectiveness of comparable units of the same type by using the method of linear programming according to multiple input indexes and multiple simulation output indexes. Instead of the standard cost of each item in piano sound simulation, this evaluation method can characterize each input and output of the simulation link through the numerator and denominator of the simulation rate ratio. This method can avoid the problem of lax evaluation of simulation quality and the calculation of audience satisfaction data in the process of piano sound simulation analysis in the traditional simulation method. Therefore, the simulation evaluation model can clearly explain the combination of input and output of simulation technology in the simulation process in China, so it is more comprehensive and reliable than the simulation scheme provided by the traditional simulation system.

On the other hand, in the process of applying different composition methods to simulate the required simulated piano sound, in order to quickly call the traditional piano sound data and store the simulated piano sound data, and realize the real-time recording of the simulation data, it is necessary to build a cloud data storage system, so that the effective information can be mined and analyzed. It is very meaningful for every piano sound simulation after that. To realize the data mining under this algorithm, the information of the target data should be translated into language information that can be recognized by the computer through a certain pattern. To solve this problem, usually, relevant technicians will use vector space model to carry out information processing of modern music field data in different target regions. The data analysis flow of piano sound simulation model based on computer composition technology is shown in Figure 1.

**3.2. Implementation of Discrete Dynamic Modeling Technology in Guqin Sound Simulation Model.** Firstly, some simulated piano sound data information needs to be discretized through the computer database information and preset automatic judgment program, so as to realize the reprocessing of secondary data information, and then cycle back and forth to form multiple clusters, and then input them into the piano sound simulation model in this research. The data analysis process is shown in Figure 2.

Secondly, some insignificant or meaningless simulation piano sound data information is deleted or removed, and recorded in the form of vector to form a special data information record, which realizes the conversion of data information into vector information and storage. For example, when the classification of similar data information is required, the comparison can be carried out according to these vectors with the function of recording special data information. When the coincidence degree meets the preset requirements, the data processing, judgment and classification of the target data can be realized.

Finally, under a certain similarity, the information comparison between the traditional piano sound data and the simulated piano sound data under different composition methods is realized. However, generally, due to the problem of computer programming, the retrieval and comparison technology in cloud data storage technology cannot reach the level of artificial intelligence. Therefore, in terms of information analysis and understanding between the data content of Guqin sound simulation with different composition methods and the simulation data information stored in the cloud, The piano sound simulation system still has some defects and deficiencies. Based on this, in order to solve this problem or improve the recognition degree of data mining technology on the piano sound simulated by different composition methods, the most commonly used method is to accurately compare and analyze through keyword statistics and different composition methods. Moreover, this statistical comparative analysis has been relatively perfect. The above method is also used to compare the data information content of the well-known piano sound simulation model. The simulation and analysis results of Guqin sound in this process are shown in Figure 3.

As can be seen from Figure 3, among the nine groups of simulation data (A-J), compared with the linear composition method and nonlinear composition method, the corresponding accuracy of the results obtained by using the mixed composition method of big data analysis is the highest, because the calculation and identification of similarity is realized by calculating the distance and included angle between different vectors. The closer the distance or the smaller the included angle, the higher the similarity of the data information contained in the two vectors. Let  $x_i = (x_{i1}, x_{i2}, \dots, x_{ip})$  and  $x_j = (x_{j1}, x_{j2}, \dots, x_{jp})$  be the observed values of different composing methods in the piano sound simulation model, then the similarity measure  $\gamma_{ij}$  and the difference  $\alpha_{ij}$  between them are

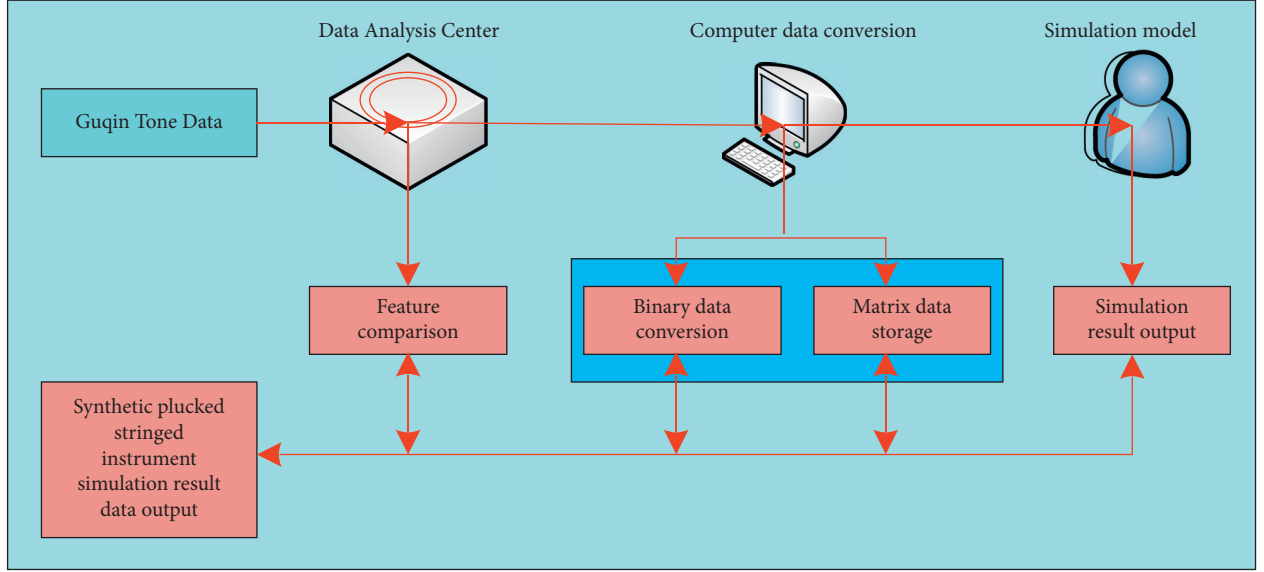


FIGURE 1: Data analysis process of piano sound simulation model based on computer composition technology.

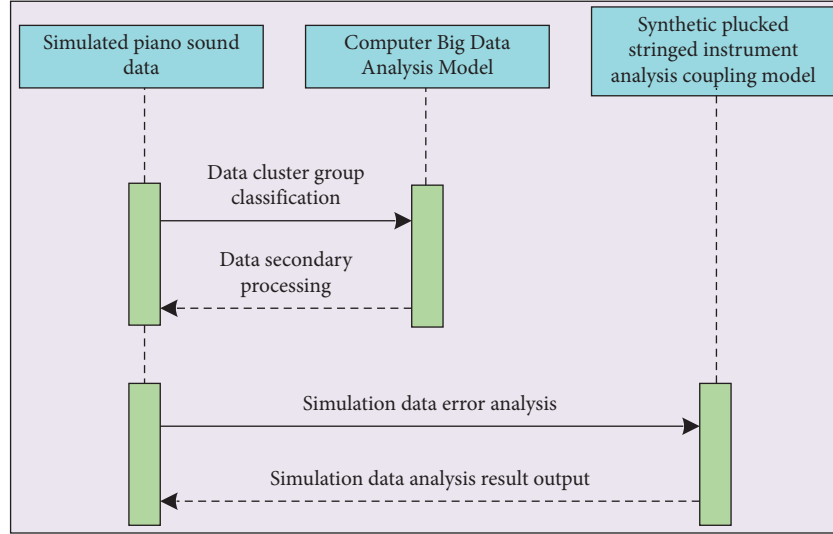


FIGURE 2: Discrete dynamic modeling technology to simulate guqin sound data.

$$\gamma_{ij} = \sum_{k=1}^p \frac{k(x_{ik} - \bar{x}_{ik})}{(k-1)(x_{jk} - \bar{x}_j)}, \quad (1)$$

$$\alpha_{ij} = \sum_{k=1}^p \frac{k}{(x_{jk} - \bar{x}_j)^2}.$$

The discrimination factor  $c_{ij}$  and discrimination coefficient  $m$  applied in the discrimination process are

$$c_{ij} = \frac{\sqrt{\sum_{k=1}^n x_{kj}^2}}{(\sum_{k=1}^n x_{ki}^2)^2}, \quad (2)$$

$$m = \sum_{k=1}^n \left( \frac{x_{kj}^2}{\sqrt{c_{ij}}} \right).$$

The coupling error is calculated as  $d_{ij}^2$ :

$$d_{ij}^2 = \frac{C_{ii}}{C_{ij}^2} + 1. \quad (3)$$

Redivide the coupling error calculation to calculate the accuracy  $\eta$  of the simulation model and the correlation coefficient  $\alpha$  between traditional data and simulation data:

$$\eta = \frac{\sqrt{C_{ij}}}{\sqrt{1 - d_{ij}}}, \quad (4)$$

$$\alpha = \frac{d_{ij} + C_{ij}}{(1 + d_{ij})^2}.$$

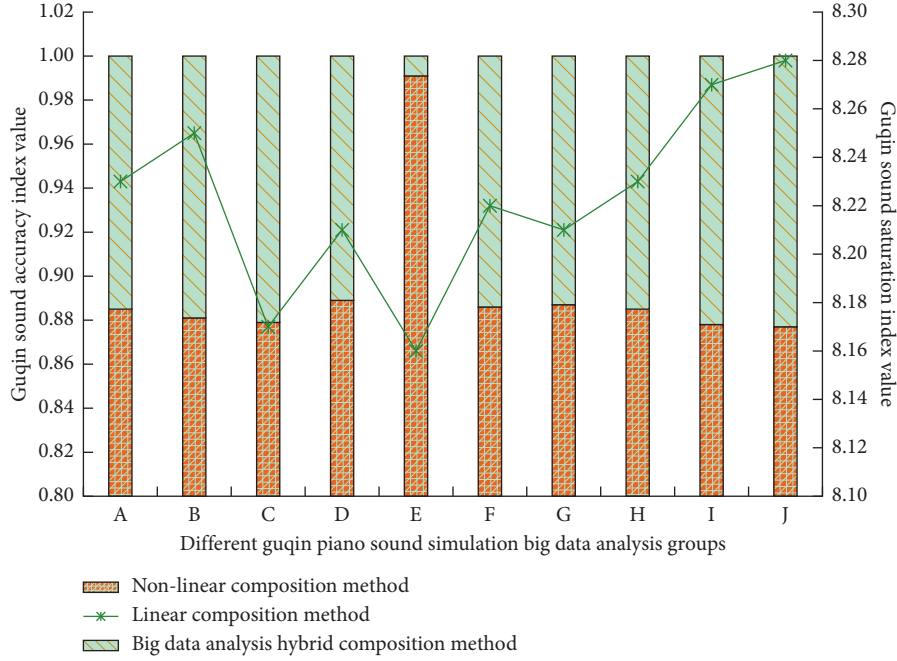


FIGURE 3: Comparison of accuracy results obtained by different test methods.

**3.3. Performance Analysis and Improvement of Big Data Simulation Model of Piano Sound Synthetic Plucked Instrument.** According to the above piano sound simulation model, we can know that the common simulation models are not optimal in analyzing the efficiency of simulation data, and there are some deficiencies. For example, they are sensitive to “noise” and outlier data, and a small amount of such data can have a great impact on the results of efficiency evaluation. In view of the problems existing in the algorithm, combined with the clustering algorithm, we make some improvements to the value evaluation model: the first is data preprocessing, the second is the selection of the initial analysis center, and the third is the selection of the optimal center threshold of the value evaluation model in the iterative process. The specific process is as follows:

The first step is to normalize the sample data, so as to prevent the distance between the left and right samples of the data of some large value attributes. Given a set of data sets containing multiple data, each data contains multiple attributes, calculate the mean and standard deviation of each attribute respectively, and standardize each data.

After standardization, the center point spacing and residual spacing of the data are calculated:

$$\sigma = \frac{\sum_{k=1}^n [x(k) - \bar{x}]}{\sum_{k=1}^n x(k)}, \quad (5)$$

$$K = \frac{x(k) - \bar{x}}{\sigma^2}.$$

In the formula,  $\sigma$  is the center point spacing after standardization,  $K$  is the residual spacing after standardization,  $x(k)$  is the data group after standardization, and  $\bar{x}$  is the data center point in the group.

The distance function of the sample is defined as  $G(k)$ :

$$G(k) = \bar{x} + \sigma \pm K. \quad (6)$$

In the second step, the selection of the initial analysis center has a great impact on the final evaluation effect. The original piano sound simulation model randomly selects multiple data as the initial clustering center, and the evaluation results of the simulation rate should be as similar as possible among the same classes, but as different as possible, so the selection of the initial center should be as different as possible. The outlier definition based on distance sum is used to prefilter outliers, and the maximum distance between two data is used to find the initial analysis center in the remaining data set. But for actual data, the number of outliers is often unpredictable. When selecting the initial cluster center, first bring the isolated points into the statistical range, calculate the distance between the two objects in the sample, select the two points with the largest distance as the two cluster centers, and then find out the distance and the largest point of all the selected cluster centers from the other sample objects as another cluster center until multiple cluster centers are selected. The simulation analysis results of the improved evaluation function on the data are shown in Figures 4 and 5.

It can be seen from the simulation results in Figures 4 and 5 that, among the evaluation results under different threshold settings (different values of  $T$ ), the difference of the evaluation results is obvious. With the increase of the threshold, the distance ratio of the cluster center of the data group gradually decreases, because this reduces the impact of the sample input sequence on the selection of the initial cluster center. Thus, the piano sound simulation model can play a more effective role in the quality inspection of simulation data. The evaluation function used in this process is defined as  $f(k)$ :



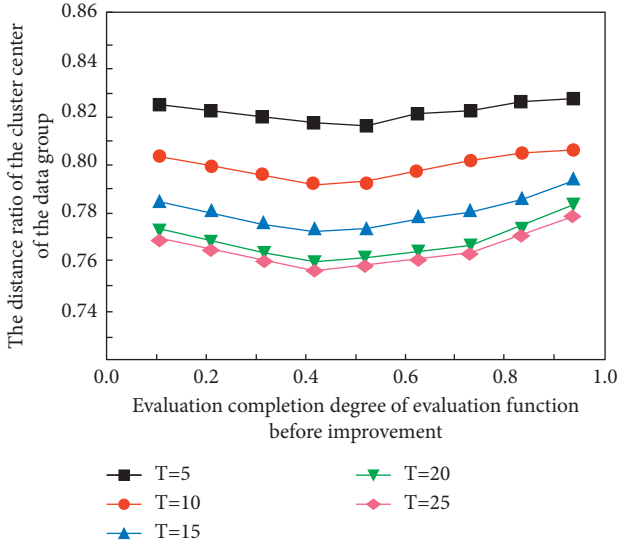


FIGURE 4: The simulation analysis result of the evaluation function on the data under different threshold settings before the improvement.

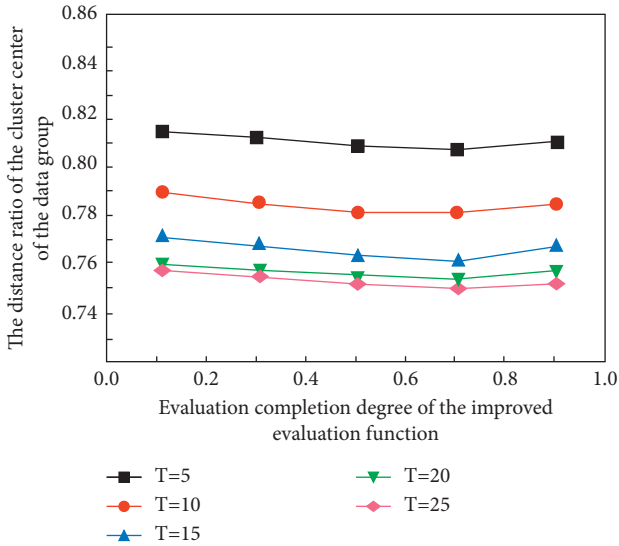


FIGURE 5: Improved simulation analysis results of evaluation function on data under different threshold settings.

$$f(k) = \frac{1}{k} (x(k) - \bar{x}), \quad (7)$$

where  $x$  is the data group and  $k$  is the quality inspection coefficient.

## 4. Result Analysis and Discussion

**4.1. Practical Test Process of Piano Sound Simulation Model Based on Computer Composition Technology.** In order to verify the practical value of the application effect of the computer simulation Guqin sound model based on Dynamic Modeling Technology in the simulation of modern

Guqin songs, take the actual public performance data of a classical Guqin song in the third quarter of 2019 as an example and test the Guqin song data simulated by the model.

The operation method used in this paper sets up six groups of different parameter models. The input piano melody data and the piano song data generated by simulation technology are divided into multiple clusters. Through the comparative analysis of different parameters and the comparative analysis of the distance and angle of converting the relevant data information into spatial vectors, it is ensured that each group of data information has high similarity and matching rate. The preliminary experimental results of the improved value evaluation model on 6 groups of experimental data are shown in Figure 6.

The preliminary experimental simulation results of the improved value evaluation model are shown in Figure 7.

As can be seen from Figures 6 and 7, with the increase of the experimental completion degree based on the dynamic modeling technology, the data information matching error index of the simulation results shows a gradually decreasing trend (55–85: the smaller the value, the smaller the error degree and the higher the accuracy). This is because in the input actual public piano sound data, Firstly, multiple target data are randomly determined as the central point of the initial clustering data set, and then the simulated piano sound data simulated by the piano sound simulation model under various composition modes are detected, and the score is analyzed by comparing the coupling error between the two. After completing the above steps, redetermine the sample center of each piano sound simulation model, determine the spatial vector of piano sound data sources simulated by different initial composition methods of the cluster, and then determine the similarity arrangement between different clusters according to the shortest distance comparison of different classes to form a cluster group with logical structure. When the simulated piano sound data generated by the last group of different composition methods in the experimental group is input, the classification processing of this group of data information is realized, and the next group of data information is judged again.

The feature items of different clusters are weighted by weight comparison, and the square difference operation is carried out. The data information similarity between clusters is based on the average value and compared with the preset standard value to realize secondary verification.

$$x^{(1)}k = \frac{x^{(0)}k - \bar{x}^{(0)}(k)}{\sum_{k=1}^n [x^{(0)}k - \bar{x}^{(0)}(k)]}. \quad (8)$$

The above formula is the operation of weighting the data.

$$s_1^2 = \frac{(x^{(0)}(k) - \bar{x}^{(0)}(k))^2}{n}. \quad (9)$$

In the formula,  $s_1^2$  is the sum of weighted square differences,  $x^{(0)}k$  is the vector to be detected in the cluster, and  $\bar{x}^{(0)}(k)$  is the standard reference vector in the cluster. The evaluation function of its optimal efficiency is as follows:

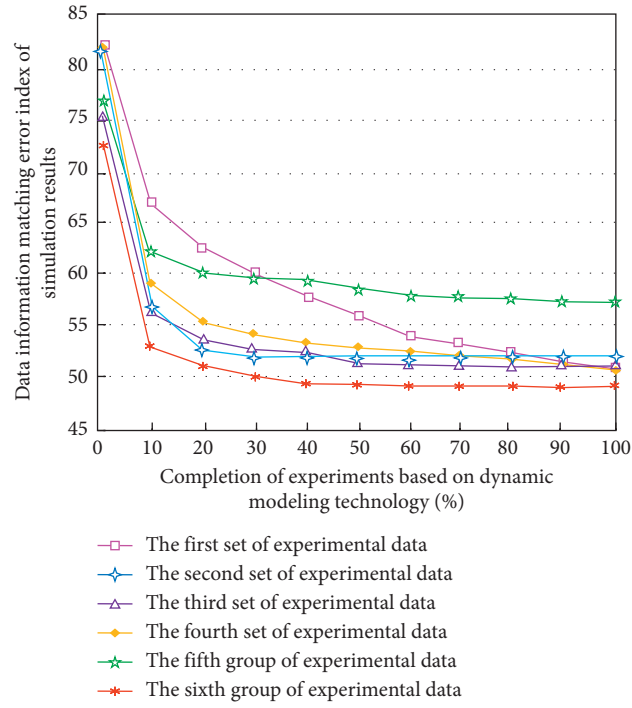


FIGURE 6: Preliminary experimental results of the value evaluation model before the improvement on 6 sets of experimental data.

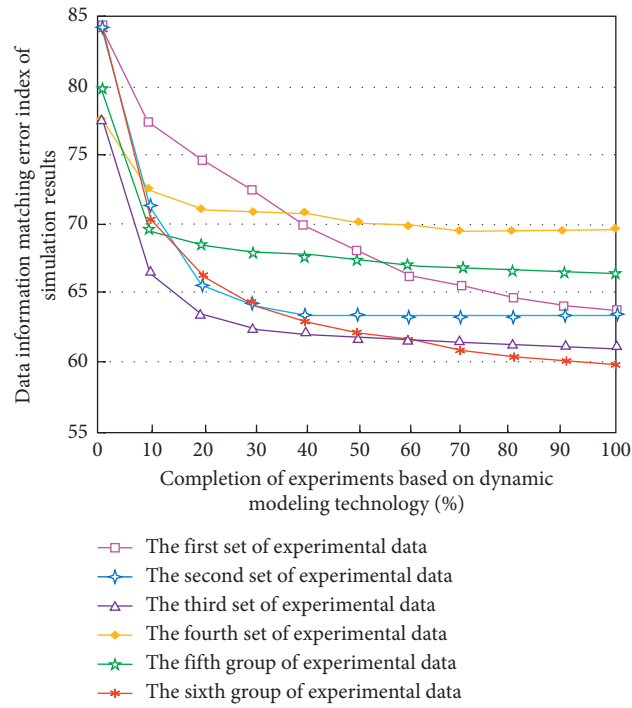


FIGURE 7: Preliminary experimental results of the improved value evaluation model on 6 sets of experimental data.

$$\begin{aligned}\bar{x}^{(n)}(k) &= \frac{\sum_{k=1}^n x^{(n)}(k)}{n}, \\ \bar{e} &= \frac{\sum_{k=1}^n e(k)}{e(0)}.\end{aligned}\quad (10)$$

In the formula,  $\bar{x}^{(n)}(k)$  is the average value processed between different clusters,  $x^{(n)}k$  is the vector processing value between different clusters,  $\bar{e}$  is the operation value between different clusters, and  $e(k)$  is the processing value in each cluster.

**4.2. Practice Verification Results and Feedback.** Since China has not adopted a unified standard for the evaluation method of modern computer simulation piano sound simulation rate, combined with the experimental results, this study takes the classic Guqin song as the experimental object, the experimental group adopts the value evaluation model, the control group adopts the evaluation model of conventional methods, and uses the hierarchical clustering method to aggregate into a clustering tree. By observing the cluster tree, we can clearly know that the similarity between the simulated Guqin sound without this simulation model and the real Guqin sound is low (see Table 1 for the data).

The quantitative results of the reliability experiment of Guqin sound synthesis plucked instrument simulation based on the experimental data are shown in Figure 8.

It can be seen from the experimental results in Figure 8 that under different iterative operation rules (1–8), the change rules in data information matching error index are different for 6 different experimental groups, because the simulation analysis algorithm adopted by computer composition technology is essentially through iterative operation results. Take the actual piano sound data and the simulation data of Guqin piano sound simulated by each type of composition mode using the simulation model as a target sample to be clustered, judge whether they belong to the same cluster through the different characteristics of the data information and the differences of cluster centers, and then analyze the correlation degree between them. So as to evaluate the simulation rate of piano sound simulated by different computer composition methods, and then realize the identification and analysis of different computer composition methods. The analysis results of simulation efficiency of experimental data are shown in Figure 9.

It can be seen from the analysis results in Figure 9 that under different iterative operation rules (1–8), the quantitative evaluation and analysis of simulation efficiency in 6 different experimental groups are different, because the 29 clustering cycle iterative calculation rules of the automatic association analysis system are different. Until the 27th simulation, the consistency verification of simulated piano sound and real piano sound through other simulation models was divided into one category. During the last evaluation of the value evaluation model, we found that the differences of the piano sounds simulated by the two different simulation methods were obviously detected, and the similarity coefficient was 0.04396. The experimental results

TABLE 1: Experimental results of the model.

Test subject	Similarity value
Audience 1	0.04396
Audience 2	0.56741
Audience 3	0.86527

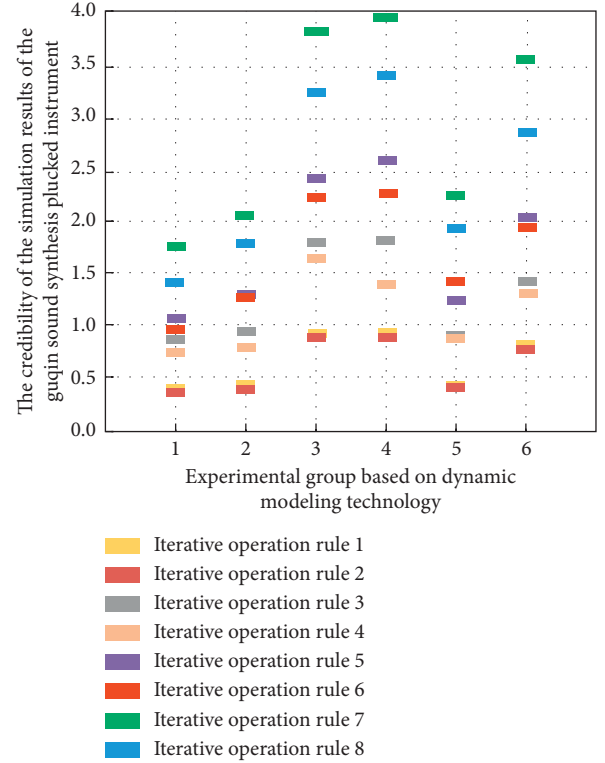


FIGURE 8: Quantitative analysis results of the credibility of the guqin piano sound synthesis plucked string instrument simulation.

showed that although the modern piano sound simulation models were similar, the piano sounds of the simulation model were not used. The data integrity difference of simulated piano sound simulated by different composition methods can still be detected by the evaluation and analysis system. However, in the current process of evaluating different composition methods and piano sound simulation quality, especially in the different simulation models of companies with different composition simulation methods, there are many cases of “high investment in computer intelligent composition simulation research and development, but poor simulation effect of piano sound.” In other words, the problem of whether the simulated piano sound simulated by different composition methods is quite different from the actual piano sound can be accurately detected. Therefore, before the automatic evaluation system program applies the piano sound simulation model to different composition methods, we should still artificially set multiple parameter thresholds for the preliminary judgment of the difference between the simulated piano sound and the actual piano sound in different composition methods. When the relevant value calculated by the system is lower than the set



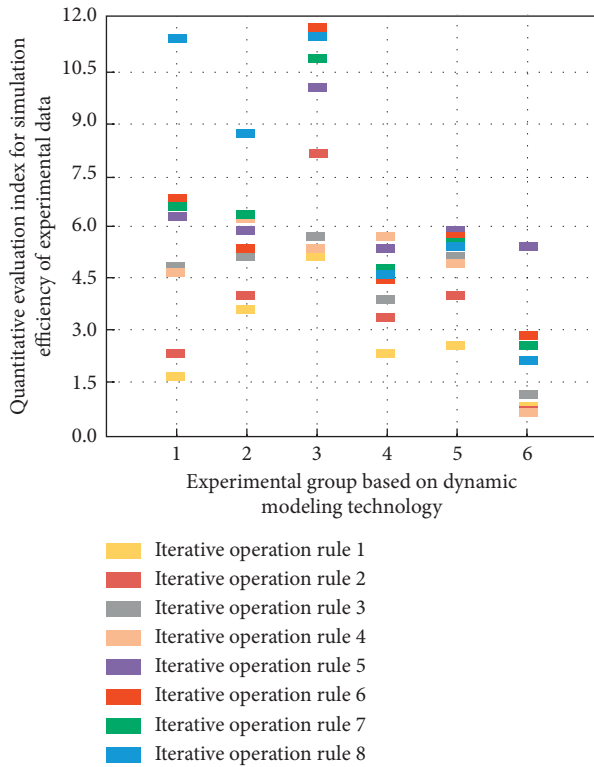


FIGURE 9: Quantitative evaluation and analysis of simulation efficiency of experimental data.

value. The system will automatically feedback the piano sound simulation segments with low simulation rate to experts for secondary simulation discrimination. Based on this, in this experiment, we set the initial similarity value as 0.76. In this way, when the piano sound simulation model is applied in different composition methods and the simulated piano sound fragments are tested and analyzed, the model can greatly improve the proofreading accuracy of the model simulated piano sound.

## 5. Conclusion

The application of traditional composition methods in the field of modern music and the evaluation model of economic efficiency can no longer meet the needs of various types of music in China, especially Guqin music. Based on this, this paper studies the big data simulation model of Guqin sound synthesis and plucking based on computer composition technology. Firstly, three characteristic parameters affecting the simulation effect of the piano sound simulation model are selected, and a computer intelligent composition technology based on discrete dynamic modeling technology is proposed, which is applied to the simulation of Guqin sound. Secondly, through three aspects: the difference of simulated piano sound under different composition methods, the simulation process of piano sound simulation model, and the difference between model simulated piano sound and actual piano sound, the piano sound simulation model is systematically evaluated from multiple angles. Finally, the piano sound simulation model is tested in

practice. The experimental results show that the Guqin chord simulation model based on computer composition technology can effectively apply different composition technologies to the piano sound simulation, and the simulation rate is as high as 99.56%. Compared with the traditional piano sound simulation model with no target simulation technology as the main simulation technology, this paper constructs a new computer composition method with the help of discrete dynamic modeling technology, and uses this technology to construct a new Guqin sound simulation model and cloud data system. The model can not only realize different kinds of piano sound simulation through different composition methods, but also upload these simulation data to the cloud system and store them. Using quantitative indicators to complete the scoring indicators of Guqin music of different audiences can efficiently carry out customized analysis on the data indicators affecting the satisfaction of different audiences. However, the research focus of this paper only focuses on the impact of composition mode on the construction and efficiency evaluation of Guqin sound simulation model, without considering the data simulation efficiency of simulated piano sound. Therefore, there are aspects to be improved in the data simulation data simulation rate of piano sound simulation model.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare that there are no conflicts of interest.

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