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Computer-Aided Design AND APPLICATIONS

Building a 5G-Enhanced Multimedia Database for Chinese Music History with Collaborative CAD

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Abstract. The informatization of music education is still in the exploratory stage, and the construction of a perfect multimedia database can effectively promote the informatization process. Using multimedia network teaching can organize all kinds of materials of Chinese music history intuitively, vividly, and scientifically, and it can improve the efficiency of study and scientific research. At present, music majors in universities have set up courses in Chinese music history, which can help students understand and respect the musical and cultural phenomena in different periods of China and broaden their knowledge. With the development of Internet technology, the storage and dissemination of information on the Internet are expanding day by day, which makes it relatively troublesome for people to search for effective information. However, the traditional search methods can't satisfy people's search for effective information in a huge information base. Developing a multimedia database of Chinese music history is the foundation of online teaching of Chinese music history. This paper uses big data to recommend music history content according to users' preferences and memories and proposes CF to solve this problem. The multimedia database of Chinese music history based on big data CF can help users find potential interests and make recommendations.

Key words: Collaborative CAD; Music history; 5G-Enhanced Multimedia database
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1 INTRODUCTION

With the increasing development of people's living standards, Internet technology plays an increasingly important role in our daily lives and has become one of the important sources from which we obtain information [4]. However, a large amount of information is flooding into the eyes of information collectors, making it more and more difficult to discover effective information, increasing the cost of information collection, which is not conducive to production activities and saving human resources [14],[11]. All kinds of music cultures have strong national characteristics and diverse artistic forms, and all have their complete and detailed development history. At the same time, they influence each other and develop comprehensively. The history of Chinese music also plays a very important role in music history teaching in universities. The teaching of Chinese music history is mainly based on theoretical teaching, and the traditional music teaching methods at this stage limit the development of Chinese music history teaching methods [1]. In recent years, the rapid development of computer, multimedia, and network technology has provided rich multimedia resources for the teaching of Chinese music history, as well as convenient conditions for reforming the teaching of Chinese music history and improving the teaching quality [7].

All kinds of music cultures have strong national characteristics and diverse artistic forms, and all have their complete and detailed development history. At the same time, they influence each other and develop comprehensively. Chinese music history is an important part of literature and history research and music research, and it also plays a very important role in music theory teaching in universities [10]. The establishment of multimedia data on Chinese music history can help a great number of text materials to be digitized, sorted according to specific inductive methods, form a series of perfect databases, change traditional recording methods, and effectively promote the development of Chinese music history [9],[15].

The establishment of a systematic, complete, and professional multimedia database of Chinese music history, which can greatly improve the teaching quality and realize convenient resource sharing and quick resource inquiry, is an important topic in the current reform of Chinese music history teaching in universities [3]. Teachers can share the teaching music history resources with students through the auxiliary system, and students can also obtain and share music history resources through the auxiliary system. Using the CF system in computer applications is to apply this idea to the information recommendation service on the Internet and make auxiliary recommendations to target users' choices by referring to other users' comments and scores on an object. Based on this, this paper proposes a music history content recommendation method based on CF. The main innovations are as follows:

1. Based on the actual development of music history, this paper studies and explores the construction of a multimedia database to provide effective strategies for the sustainable development of music history.

2. This paper analyzes the construction goal of a multimedia database of Chinese music history in universities and puts forward the construction method of the multimedia database based on big data CF.

The first section introduces the research background of multimedia database construction of Chinese music history and puts forward the method and innovation of this paper. The second section analyzes the contribution of scholars to the field of information recommendation and teaching databases and then puts forward the construction strategy of a multimedia database of Chinese music history based on CF. The third section is the method and model part. Combining CF, the multimedia database model of Chinese music history is constructed, and the personalized recommendation of content is realized. In the fourth section, simulation experiments are carried out to verify the effectiveness of the CF method in this paper. The fifth section is the conclusion, which summarizes the contribution of this paper and puts forward the limitations of this method and the direction of further research.

2 RELATED WORK

In the teaching assistance system, it is very necessary to integrate the recommendation system of instructional resources. This can improve the utilization of instructional resources. Sayg pointed out the drawbacks of the early distance learning system. With the development of Internet applications, more and more people put the learning process on the Internet, and students can enjoy the services provided by online school without leaving home [16]. From the perspective of knowledge management, Thompson et al. analyzed and discussed the construction of a personalized instructional resource base and proposed that the construction of an instructional resource base in distance education not only includes the construction of static instructional resources such as network courseware and teaching materials [17]. The valuable, personalized, and fluid dynamic instructional resources generated by learners in the process of learning should also become important content for the construction of an instructional resource library. Yang pointed out that the multi-level, diversified, open, and dynamic update timeliness of the construction of the instructional resource library should be considered in the construction of the instructional resource library so that different learners can obtain the resources they need in the instructional resource library [20],[19]. Dominguez et al. developed a related music recommendation system and recommended it to users. According to the user's rating information, they classified which songs were liked and which songs were not liked [6]. Xie believes that learners are faced with an ocean of instructional resources, and they must learn to filter instructional resources, abandon those instructional resources that have no or little impact on their own learning, and obtain instructional resources that meet the learners' learning needs accurately and quickly [18]. Yao individual information retrieval system based on distributed agent technology and relevant feedback learning [21]. Lan defines the user's teaching background information from the user's registration information and then obtains the user's interest direction through the user's browsing behavior to determine the user's interest model [12]. Jackson adopts a combination of content-based recommendation and CF recommendation algorithm to build a recommendation module and designs and implements a prototype of the system [8].

3 METHODOLOGY

3.1 Present Situation of Chinese Music History Teaching

In the long development of history and culture, the content of Chinese music has formed a unique Chinese music history. However, due to the tedious content, difficult use, and complicated sorting, it will cost a lot of manpower and material resources [13]. Nowadays, many music majors in music colleges take Chinese music history as a compulsory course. However, first of all, the history of Chinese music has been continuously enriched with the passage of time, and it has become a huge part of the history of music and culture. According to the original teaching settings in universities, it is impossible to give a detailed introduction to Chinese music history, and students' mastery of the content of Chinese music history is also very limited. Teachers can share the teaching music history resources with students through the auxiliary system, and students can also obtain and share music history resources through the auxiliary system. The rapid development of computer and multimedia technology has provided rich music history resources for the teaching of Chinese music history in universities and also provided a new method for reforming the teaching methods of Chinese music history. At present, the digitalization and integration of professional music resources in universities lag behind other majors, and the resources among universities can't be shared, and the music materials available on the Internet are few and far between. To solve this problem and meet the needs of people, building a multimedia database of Chinese music history has become the most effective solution, fundamentally changing the problem of lack of materials and having a great influence on the inheritance and promotion of Chinese music culture history and the development of Chinese music history.

3.2 Content Recommendation of Music History Based on Big Data CF Technology

The multimedia database of Chinese music history effectively organizes and manages massive music history resources and provides users with convenient and quick personalized services [5]. A large amount of data is usually structured, but sometimes it is semi-structured or unstructured. The output from the output module is usually the prediction score result or the item recommendation result. In order to achieve the accuracy of recommendation, the user data is combed and then mined and analyzed. In this process, multi-source data fusion is an indispensable step, making full use of the diversity of data sources. And combined with CF to provide recommendation services for users.

Using the CF system in computer applications to apply this idea to the information recommendation service on the Internet and make auxiliary recommendations to target users' choices by referring to other users' comments and scores on an object. Based on this, this paper proposes a music history content recommendation method based on CF. Because the database recommendation system thinks that the user's interest has not changed, it will lead to recommending items to users many times and even lead to users' boredom. The user's interest is not static. Due to complex environmental factors and the influence of time, the user's values and preferences will also change. That is, the user's interest drifts. The essence of the recommendation system is a tool based on users' historical behavior data, which is used to analyze the items that users are interested in and generate recommendation lists. The overall steps of the database recommendation system are shown in Figure 1.

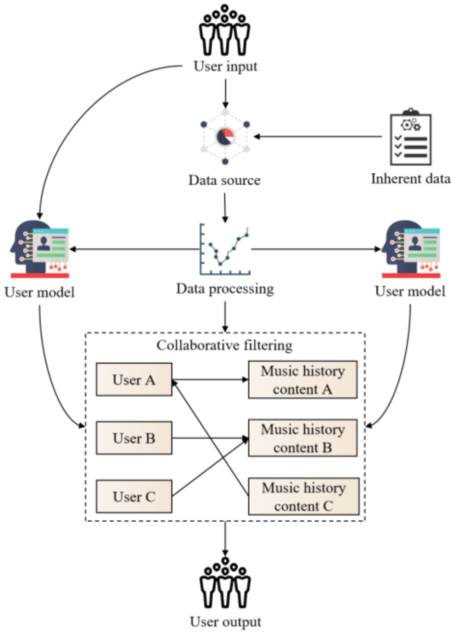

Figure 1: Database recommendation system steps.

Assuming that the user set is represented by U, and I represents the set of items, the recommendation degree of the item i to the user u can be represented by the function S. Then, the recommendation algorithm can be expressed as:

$$\forall u \in U, i' = argmax\, S_{i \in I}\,(u, i) \tag{1}$$

Where u is the user, U is the user set, i is the item, I is the item set, and S is the degree of recommendation of the item to the user.

Suppose the user U_i and user U_j vectors are $\vec{i}$ and $\vec{j}$ respectively, then the formula for calculating the cosine similarity between two users can be expressed as:

$$\mathrm{sim}(u_i,\mathrm{u}_j)=\cos(\mathrm{i,j})=\frac{\vec{i}*\vec{\mathrm{j}}}{\|\vec{i}\|\times\|\vec{j}\|} \tag{2}$$

Where: $\vec{i}$ is the vector of user U_i, and $\vec{j}$ is the vector of user U_j.

Users' interests are dynamic and will change with the advancement of learning. Through the tracking of user behavior, the user interest model can be updated to ensure that the user interest can be grasped in real-time, and on this basis, the corresponding personalized service can be provided. Information supplement technology, including original information adjustment, is adopted to update the user's interest model. That is, the change of the user's interest is obtained through user's behavior analysis, and the weight of corresponding interest features is adjusted to reflect the change of user's interest. Take the average score of users as a reference, and the specific calculation process is:

$$\mathrm{sim}(u_i,\mathrm{u}_j)=\frac{\sum\in I_{u_i,u_j}\left(R_{u_i,j}-\vec{R}_{u_i}\right)\left(R_{u_i,j}-\vec{R}_{u_j}\right)}{\sum i\in\in I_{u_i,u_j}\left(R_{u_i,j}-\vec{R}_{u_i}\right)^2\left(R_{u_i,j}-\vec{R}_{u_j}\right)^2} \tag{3}$$

In the formula: I_{u_i,u_j} is the evaluation score set of user U_i and user U_j, $R_{u_i,i}$ is the evaluation score of user U_i on item i, $R_{u_j,i}$ is the evaluation score of user U_j on item i, $\vec{R}_{u_i}$ is the average score of user U_i historical evaluation, $\vec{R}_{u_j}$ is the user. The average score of U_j's historical evaluation.

The model-based CF recommendation algorithm does not directly calculate the similarity between users or items but is based on a statistical model or machine learning method. Enter the target users' ratings of other resources, and you can quickly and accurately generate recommendation results. User-based CF recommendation algorithm As the number of users increases, finding similar users among a great number of users will become the bottleneck of the whole algorithm. CF recommendation algorithm replaces the similarity between users by calculating the similarity between resources. The similarity between resources is much more stable than that of users. The similarity calculation between resources can be completed offline, which can reduce the online calculation and improve the efficiency of recommendations.

3.3 Construction of a Multimedia Database of Chinese Music History

To establish an effective and efficient multimedia database, we must first understand and analyze the requirements of users. Individual information service is a kind of service that provides users with various personalized needs according to their usage behaviors, habits, preferences and characteristics. The analysis of users' needs is to survey, research, and summarize the people who use Chinese music history more frequently. It establishes a database more quickly and, builds a multimedia database more suitable for the masses, and realizes the real value of the database. Individual information service systems can learn to generate users' personalized models and can use users' personalized models to reason and learn the behaviors of users and information sources.

The core idea of CF based on users is that people's behaviors are similar, users with similar behaviors will make similar choices, and users' behaviors contain users' interest information. The algorithm finds the neighboring users through their preference for resources and then recommends the resources that the neighboring users like to the current users. The general process of establishing CF system based on users is shown in Figure 2.

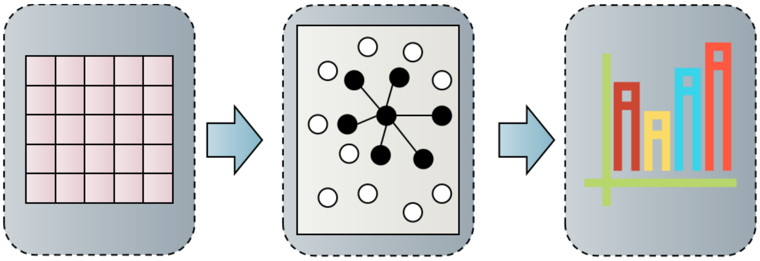

Figure 2: CF recommendation algorithm based on users.

Model-based CF does not need to calculate the similarity of users in real-time at first but predicts the interest preferences of target users by using pre-built models. At the same time, the establishment of the model also makes the recommendation results more intuitive. Secondly, this method can effectively alleviate the real-time problem of the recommendation algorithm because the established model is much smaller than the original data set. In order to solve the sparseness caused by item-based CF recommendation, the system combines content-based recommendation and item-based CF recommendation algorithm to recommend personalized music history resources.

Consider the user rating as a vector on the n -dimensional item space, and set the rating to 0 if the user assigns a certain item. The larger the cosine value of user i and user j is obtained by calculating the cosine angle between the vectors, the higher the similarity between the two users is. Let the rating vectors of user i and user j be $\vec{i}$ and $\vec{j}$, then the similarity between users is:

$$Sim(i,j) = cos(\vec{i},\vec{j}) = \frac{\vec{i}\cdot\vec{j}}{\|\vec{i}\|\|\vec{j}\|} \tag{4}$$

LetI_{ij} represent the set of items that user i and user j have jointly rated, I_i andI_j are the set of items scored by user i and user j, respectively, and the calculation of user i and user j to adjust the cosine similarity is:

$$Sim(i,j) = \frac{\sum k\in I_{ij}(R_{i,k}-\bar{R}_i)(R_{j,k}-\bar{R}_j)}{\sqrt{\sum k\in I_i(R_{i,k}-\bar{R}_i)^2}\sqrt{\sum k\in I_j(R_{j,k}-\bar{R}_j)^2}} \tag{5}$$

Among them, $R_{i,k}$ represents the evaluation value of the item k by user i, and $\bar{R}_i$and$\bar{R}_j$ represent the average rating of the item by user i and user j, respectively.

By obtaining the nearest neighbor set S_u of the target user, the user's rating $P_{u,i}$ for the item can be predicted.

$$P_{u,i} = \bar{R}_u + \frac{\sum_{n\in S_n} \mathrm{Sim}\,(u,n)\cdot(R_{n,i}-\bar{R}_n)}{\sum_{n\in S_u} \mathrm{Sim}\,(u,n)} \tag{6}$$

Among them, $\bar{R}_i$ and $\bar{R}_j$ represent the average rating of the item by user i and user j, respectively, $\mathrm{Sim(u,n)}$ represents the similarity between user u and user n, and $R_{n,i}$ represents the rating of user n on item i.

As shown in Figure 3, its storage layer intuitively represents the storage of multimedia data of music history in the system. As the backup data management organization of the whole system, it must have good stability and large capacity.

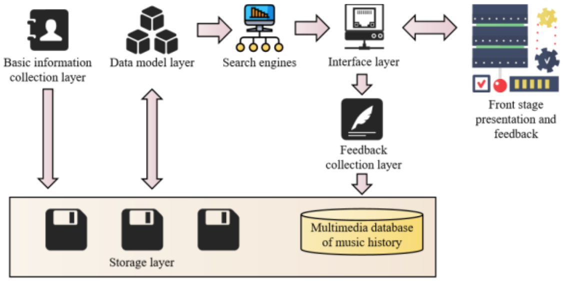

Figure 3: System architecture.

After the establishment of the model, the resources and scoring information of the database may have changed greatly, but the model can't reflect the real situation of the database. In order to ensure the practicability of the model, the model must be periodically updated and re-established, so the computational complexity of CF based on the model is very high. When a user browses and selects a favorite item in the system, the system will track and record it. Through the user's behavior record, a brief prototype of the user's behavior preference and interest model can be obtained. Based on this, relevant content can be recommended for the user, and the user's accurate behavior pattern and interest preference can be further obtained through the feedback information from the user on the recommendation list.

When constructing the neighbor set, each neighbor is weighted according to the category correlation between the current sample e_j to be predicted and its neighbors. The weight calculation formula is:

$$sw_{i,j} = \sum_{c_g \in S(c_g)} CR_{cg}(e_i) \times CR_{cg}(e_j) \tag{7}$$

e_j represents a certain sample in the neighbors, $sw_{i,\ j}$ represents the weight of the sample e as the neighbor of the sample e_j to be predicted, and $CR_{cg}(e_j)$ represents the class correlation between the sample to be predicted and the class c_g. An optimized strategy is to remove all categories c_g of $CR_{cg}(e_j) < y^{\prime}$ from the category set.

Score similarity weighting. The rating similarity $\mathrm{sim}(i,\ j)$ is weighted with the category association weight $sw_{i,j}$:

$$sim^{\prime}(i,j) = sw_{i,j} \bullet sim(i,j) \tag{8}$$

Construct the K nearest neighbor set with weighted post-score similarity. All sample e_i of $CR_{cg}(e_i) < y'$ are removed from the neighbor set. Finally, the prediction score of the samplee_i to be predicted is calculated.

The calculation process of Mean absolute error (MAE) is as follows:

$$MAE = \frac{\sum_{i=1}^{n} |R_{u,i} - r_{u,i}|}{N} \tag{9}$$

In the formula: $R_{u,i}$ is the predicted rating of the item $i$by the user u, $r_{u,i}$ is the actual rating of the item i by the user u, and MAE is the average absolute error.

The accuracy rate is calculated as follows:

$$\mathrm{Precision} = \frac{\mathrm{TX}}{\mathrm{TX+FX}} \tag{10}$$

In the formula: TX is the number of targets that are classified and actually included in the class area, NX is the number of targets that are neither classified nor included and not included in the class, and FX is the class that has been classified and is not included in the class, NFX is the number of targets that are not classified into the class but are included in the class.

The establishment of a Chinese music history database is not only a simple integration of data but also a learning platform for music history. In the development of Chinese music history, many knowledge points are included in the unique cultural background, which intersects with other related academic fields, and some even cover foreign music cultural knowledge. Therefore, when using the database to query knowledge points, the feedback results don't know that they contain relevant introductions, including that all cultural systems with intersection points should be integrated and related. As multimedia covers a variety of data forms, there are many storage forms, processing types, and reading ways in the process of digital library integration. Only by standardizing all materials and unifying standards can the database be shared and used to the greatest extent. Standardize the materials in the storage and database and collect them again after unifying the standards, such as the unification of material format, the standard of storage form, and the consistency of the same type of presentation. The operation of this program can help to establish an excellent database and standardize its later use.

4 RESULT ANALYSIS AND DISCUSSION

Digitization and standardization are the basic work of multimedia databases and the premise of multimedia data organization, management, and application. Because all the data stored by computers are in digital format, it is necessary to convert various media into digital format, which is convenient for computer storage, organization, and application. The content selection of the Chinese music history database must have a basis. The collected data must be comprehensive, accurate, and scientific, in line with the curriculum and textbook selection of domestic music colleges. For each user, randomly keep 20% of the scores in the test set and put other scores in the training set. The statistics of the result data set are shown in Table 1.

Data set	*Subscriber number*	*Quantity of articles*	*Total quantity*	*Ratio (%)*
Music history-1m	*6065*	*7825*	*1m*	*22.95*
Music history-10m	*69825*	*11318*	*10m*	*16.84*
Music history-20m	*136944*	*25782*	*20m*	*15.51*

Table 1: Pre-processed music history data set.

Vivid portal page design can stimulate users' interest in learning, and perfect query and retrieval method is the key factor to maximize the use of database resources. Therefore, the web database portal page must be designed with the idea of facing users. A 5*5 user-tag interest matrix can be calculated, as shown in Table 2.

	t1	*t2*	*t3*	*t4*	*t5*
u1	*2.2231*	*2.1233*	*1.4561*	*1.8931*	*0.9658*
u2	*1.4264*	*1.6785*	*2.4131*	*2.0404*	*1.7599*
u3	*1.2038*	*2.2231*	*0.9807*	*1.4838*	*2.5146*
u4	*1.6625*	*0.7548*	*1.4216*	*1.1765*	*0.7328*
u5	*0.7834*	*0.9526*	*1.6538*	*1.2155*	*0.8466*

Table 2: User-Tag Interest Matrix.

In this paper, for the construction method of a multimedia database of Chinese music history based on CF, a control experiment was set up, and the traditional method of literature [14] and literature [16] were used as the control group. The test results are shown in Figure 4.

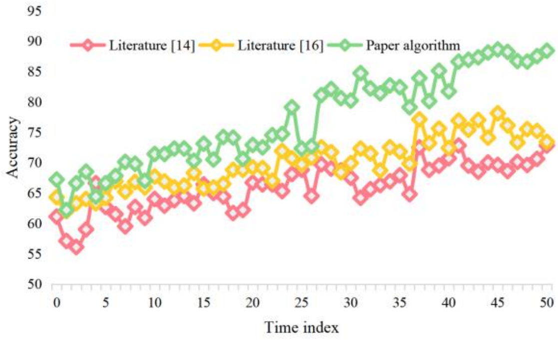

Figure 4: Accuracy comparison of algorithms.

As can be seen from Figure 4, although the CF in this paper has no obvious advantages in the early stage of algorithm operation, when the algorithm keeps running, the accuracy rate of this algorithm is significantly higher than that of the other two algorithms, reaching 89.95%. Figure 5 shows the change in accuracy of the time factor with different values between 0 and 1.

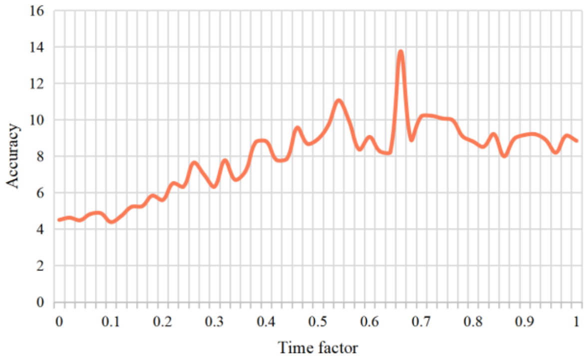

Figure 5: Relationship between time factor and accuracy.

It can be seen that the accuracy rate increases first and then decreases with the increase of the time factor. When the time factor is 0.65, the accuracy reaches the peak, so the best time factor is 0.65.

The resource collection of music multimedia databases is arduous, involving many kinds and quantities of media, and each unit or individual may only have some resources. If the sharing of database resources is not considered, it will cause serious, repeated investment and waste a lot of financial and material resources. While developing the multimedia database of Chinese music history, under the overall construction plan of the music discipline, we should consider the secondary development and reuse of multimedia data and enhance the simplicity and integration of the system. Figure 6 shows the comparison of the recommendation recall rate between this algorithm and the traditional algorithm.

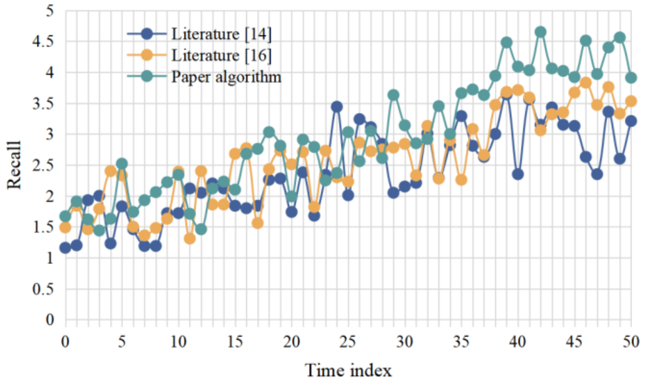

Figure 6: Comparison of recall rates of algorithms.

It can be seen that the whole recommendation set grows with the increase of its length, but the recommendation effect of this algorithm is better than that of the other two traditional recommendation algorithms. Compare the MAE algorithm with the traditional algorithm, as shown in Figure 7.

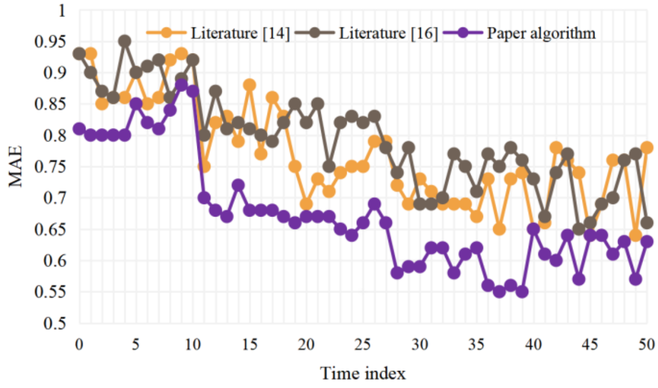

Figure 7: MAE comparison of algorithms.

The multimedia database of Chinese music history, which combines multimedia technology with Chinese music history teaching closely, realizes the diversification of inquiry means and resource sharing, and avoids the waste of manpower and financial resources caused by repeated investment, can greatly promote the development of the Chinese music history curriculum. CF recommendation, which combines the time factor with the user's interest degree, has different recommendation effects when the weight coefficient is different. Taking the value of the weight coefficient as a variable, the relationship between MAE and the weight coefficient in Figure 8 can be obtained.

Figure 8 intuitively shows that the changing trend of MAE decreases first and then increases with the increase of the weight coefficient. When the weight coefficient is 0.6, the value of MAE is the smallest, and the recommendation effect is the best. That is, when the weight of the recommendation based on the user's interest is 0.6, the recommendation effect is the best.

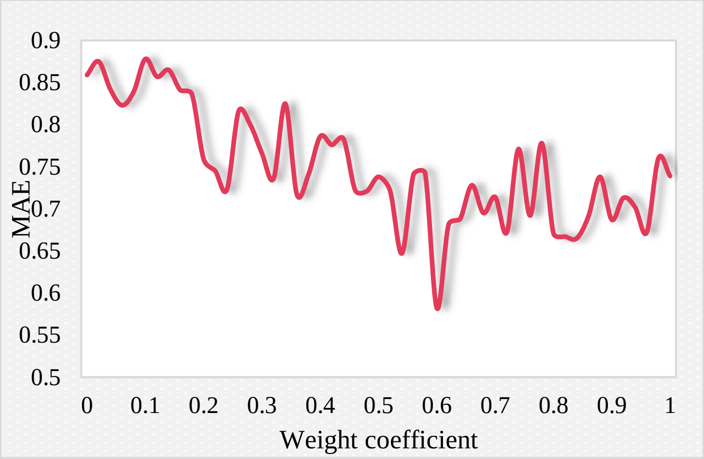

Figure 8: The relationship between MAE and weight coefficient.

Comprehensive test results show that the CF in this paper has high accuracy and low error performance and can be applied to the construction of a multimedia database of Chinese music history. Comprehensive test results show that the CF in this paper has high accuracy and low error performance and can be applied to the construction of a multimedia database of Chinese music history.

5 CONCLUSIONS

The database of Chinese music history is only a useful exploration for the construction of a music information network and the networking of music education under the information condition. This paper uses information means to recommend music history content according to users' preferences and memories and puts forward CF to solve this problem, thus providing rich network teaching and scientific research resources. The resource collection of music multimedia databases is arduous, involving many kinds and quantities of media, and each unit or individual may only have some resources. If the sharing of database resources is not considered, it will cause serious, repeated investment and waste a lot of financial and material resources. The multimedia database of Chinese music history, which combines multimedia technology with Chinese music history teaching closely, realizes the diversification of inquiry means and resource sharing, and avoids the waste of manpower and financial resources caused by repeated investment, can greatly promote the development of the Chinese music history curriculum. Although some databases of various topics have been built, the construction of the Chinese music history database is still in the exploratory stage, and there is little experience that can be used for reference. Therefore, in the process of database construction, learning, and extensive communication should be strengthened, and closed doors should be avoided. By leveraging the power of 5G technology, we have unlocked new dimensions of access and interactivity. Users can now immerse themselves in the melodies of the past, exploring historical records, audiovisual materials, and a wealth of resources with unparalleled ease and real-time responsiveness.

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