Research Article

Application of Prediction Model Using Parallel Computing in Music Cultural Facilities

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The important carrier of urban music and cultural activities is urban music and cultural facilities. In today’s environment of rapid urban development and continuous acceleration of people’s pace of life, the previous problems of music and cultural facilities with out-of-order combination, unbalanced layout and distorted scale cannot meet the basic music and cultural needs put forward by citizens. Therefore, more and more people begin to expect a reasonable layout of music and cultural facilities in their living environment. For this problem, this paper uses the prediction model of parallel computing when applying music and cultural facilities. The proposed model takes Chongqing as the research object and analyzes the construction of music and cultural facilities in various districts of the Chongqing. We investigate the specific number of music and cultural facilities in various districts and the surrounding population. Furthermore, we study whether the equipped music and cultural facilities meet people’s actual needs. Form our evaluation, it is concluded that certain districts of the Chongqing have rich educational facilities, while other districts have a very balanced distribution of music and cultural facilities, and there are different degrees of imbalance in music and cultural facilities in other regions. Through analyzing the fairness of music and cultural facilities, the Lorentz curve of music and cultural facilities is drawn based on the population proportion of each region, and the Gini fairness coefficient is calculated to be 0.53. The attractiveness of the music and cultural facilities in Chongqing is analyzed according to the road traffic and public transportation of each region.

1. Introduction

With the rapid improvement of people’s quality of life and level, while economic development can ensure people’s basic life and physiological needs, some people begin to pursue cultural enjoyment. Music plays a special role in shaping the city’s economy and culture. Each city’s music culture is different, which is directly related to the city’s history, region, and culture. This paper selects the parallel computing prediction model to generate an abstract computing model by abstracting the basic characteristics of music cultural facilities. At the same time, the parallel computing model provides basic software pages and hardware for parallel computing music cultural facilities, which can accurately analyze music cultural facilities, improve urban cultural atmosphere, and build a metropolis with music characteristics.

In today’s environment of rapid urban improvement and unremitting speeding up of people’s pace of life, the preceding problems of music and cultural facilities with out-of-order combination, unbalanced layout, and distorted scale cannot meet the basic music and cultural needs put forward by citizens. Therefore, more and more people begin to expect a reasonable layout of music and cultural facilities in their living environment. For this problem, certain prediction models, which are based on the parallel computing, have been suggested. These models could analyze the construction of music and cultural facilities in various districts, and investigate the specific number of music and cultural facilities in various districts and the surrounding population. There has been rich literature that investigates whether the equipped music and cultural facilities meet people’s actual needs. However, due to the huge amount of data, parallel computing is not utilized. There are many types of predictive
control algorithms and different expression types. However, they all have the same three basic functions, namely, (i) rolling optimization, (ii) model prediction, and (iii) feedback correction [1]. The basic concept of the model predictive control (MPC) refers to the prediction model and measurement information at a particular time $k$. In subsequent step, the controller predicts the subsequent dynamic behavior of the system and solves the open-loop control sequence based on the preset constraints and open-loop performance objective function.

In this paper, the prediction model of parallel computing is used in music cultural facilities for analysis. Through briefly introducing the basic principle of prediction model control and mathematical calculation method, the parallel computing process is explained, and the algorithm is applied to music cultural facilities. We also establish the optimal layout model of music and cultural facilities, analyze the components and types of music and cultural facilities, judge the situation of urban construction of music and cultural facilities through the model and attraction model of music and cultural facilities, and point out the imbalance [1]. The main innovations of this paper are as follows:

(i) A prediction model based on the well-known parallel computing is used in music cultural facilities for analysis

(ii) Introduce the basic principles of prediction model control and mathematical calculation method, a parallel computing-based algorithm is applied to music cultural facilities

(iii) Analyze the components and types of music and cultural facilities, judge the situation of urban construction through the equity and attraction model, and point out the imbalance

The remaining of the article is organized in the following manner. In section 2, state-of-the-art-related work is illustrated. In section 3, a prediction model is proposed that is based on the well-known parallel computing platform. A mathematical proof of the model is also illustrated. Moreover, we also offer a brief introduction of the parallel computing. In section 4, the optimal layout model of music and cultural facilities is discussed. Applications of the proposed prediction model based on parallel computing in music cultural facilities are discussed in section 5. Finally, we conclude this study along with future research directions in section 6.

2. Related Work

The model predictive control (MPC) is an advanced control technology that is based on explicit process model. The main purpose of the MPC is to predict and estimate the future process behavior by combining measurable information and process dynamic model. Furthermore, it reduces the gap between the predicted process response and design response [2]. Nowadays, parallel computing technology is widely used in many intensive application fields. American scholars choose Cray XD 1 supercomputer manufactured by Cray company to study the parallel system of processing unit matrix operation based on general processor hybrid design and FPGA [3]. Subsequently, the American scholars put forward a parallel algorithm of matrix multiplication used in shared memory system and cluster environment [4]. Wang R et al. proposed a master-slave distributed matrix multiplication parallel computing system based on PCI interconnection and FPGA as processing unit [5]. Shuangxia et al. and other experts studied the parallel matrix algorithm based on heap multiprocessor [6]. According to the concept given by C. A. Almasi et al., parallel computing platform is a system formed by interconnecting multiple processing units with a certain structure.

The communication ability between units in the system is strong, and a large number of calculations can be realized through cooperation [7]. At the same time, some experts conducted research on cultural facilities. For example, Shi J R et al. deeply studied the feedback process and driving force of cultural innovation and transformation projects of French tobacco factories. As a result, the authors put forward the replacement mode of industrial heritage and cultural facilities [8]. Chang et al. believed that tourists pay most attention to the cultural facilities, so it is necessary to strengthen facility management to improve tourists’ attention. Managers should also strengthen facility management and greatly improve the service level of facilities to meet the basic needs of the tourists [9]. Fei et al. proposed that the memorial hall has strong autonomy, opening-up ability, and high degree of transformation service equipment from the demand, which carries the main connotation of the city and residential area. In fact, this is also the foundation of establishing urban culture and serves as an important spatial carrier for people’s cultural exchange [10].

Simone et al. proposed that the cultural facilities, as an important part, form an urban smart intensive area [11]. Similarly, Jia et al. pointed out from the degree and output of the cultural consumption in Europe that cultural facilities are the main measures to strengthen urban capital and display urban image. Both the higher education people and the middle class will consume around cultural facilities, and they are the main group of cultural consumption [12]. When studying Singapore, Kharvari et al. pointed out that the city attaches great importance to the cultural construction and the improvement of cultural facilities, which is an important driving force for innovation and development in the region. During the parallel development of cultural and educational facilities, the layout of cultural facilities also has a direct impact on people’s living areas [13].

Chinese scholars use temporal and spatial differentiation to analyze the comprehensive cultural facilities in the urban area of Beijing, and study the factors of cultural facilities distributed in different stages in Beijing from the time dimension. The comprehensive cultural facilities involve economic, transportation, and densely populated areas, which could essentially help in providing the necessary conditions for the aggregation of cultural facilities [14].
3. Prediction Model Based on Parallel Computing

3.1. Overview of Model Predictive Control. In the 1960s, a new computer control algorithm, that is, model predictive control (MPC), was proposed in the industrial field of Europe and America. Moreover, MPC is combined with industrial practice to form a control mode. The MPC mode has low requirements for model accuracy and can be used in non-minimum phase systems and time-delay objects. Similarly, it has good tracking performance and is more ideal than the traditional adaptive control and optimal control. In fact, the MPC can be applied in more complex industrial engineering control to meet the basic needs of the environment. Model predictive control can deal with control problems with constraints easily and flexibly, and has become the core of theoretical circles and industrial fields at home and abroad. The following figure is a 1-bit model predictive control system diagram in which \( u(t|t) \) represents the use of model predictive controller in the controlled output of the system, \( y(t) \) represents the system response, and \( y_{ref} \) represents the system response track set in advance which is shown in Figure 1. Therefore, the basic characteristics of model predictive control can be summarized as: (i) rolling optimization, (ii) predictive model, and (iii) feedback correction.

3.2. Basic Principles of the Model Predictive Control (MPC). There are many types of predictive control algorithms and different expression types. However, they all have the same three basic functions, namely, (i) rolling optimization, (ii) model prediction, and (iii) feedback correction [15]. The basic concept of the model predictive control refers to the prediction model and measurement information at time \( k \). The controller predicts the subsequent dynamic behavior of the system in the \([k, k+p]\) time domain and solves the open-loop control sequence based on the preset constraints and open-loop performance objective function in \([k, k+m]\) (\( m < p \)), as shown in Figure 2. The first open-loop control sequence element is applied to the physical system. Moreover, the \( k+1 \) time is optimized according to the new measurement information in order to find a new control sequence. Figure 2 shows the basic principles of the model predictive control, where \( m \) is the control area and \( p \) is the predictive time domain.

3.3. Mathematical Description of Model Predictive Control. The traditional MPC algorithm is an open-loop prediction. The following is the basic mathematical form of the open-loop optimization problem of the model predictive control:

\[
\begin{align*}
\min_{\Delta U(k)} J(y(k), \Delta U(k)), \\
\text{s.t. } y(k+1) = f(y(k), u(k), d(k)), \\
\text{s.t. } y(k+1) = f(y(k), u(k), d(k)), \\
y(k) \in Y, \quad k \geq 0,
\end{align*}
\]

(1)

(2)

(3)

Here, we would like to highlight the entire process in three steps:

1. In formula (6), \( J \) represents the control performance index function, and the performance index commonly used in MPC is the quadratic objective function. The basic form is represented by the following equation [16]:

\[
J = \sum_{i=1}^{p} \| y(k+i|k) - r(k+i) \|_Q^2 + \sum_{i=0}^{m} \| \Delta u(k+i-1) \|_R^2.
\]

(6)

The above formula \( m \) represents the control time domain, \( p \) represents the prediction time domain, usually \( m < p \); \( R \) represents the control increment weighting matrix, and \( Q \) represents the prediction error weighting matrix. The first direction in this form of performance index is the sum of the squares of the later \( p \) different sampling time prediction outputs minus the given value or time-varying reference trajectory difference; the second term is to accumulate all the values of the gain of the next \( m \) control variables.

\[
\Delta U(k) = [\Delta u(k)\Delta u(k+1), \ldots, \Delta u(k+m-1)]^T.
\]

(7)

Formula (7) is a sequence of control increments, which is an independent variable of the optimization problem.

2. Formula (2) is the discrete model of the controlled system, where \( y(k) \in \mathbb{R}^p \) represents the output vector, \( y(k) \in \mathbb{R}^p \) represents the input vector, and \( d(k) \in \mathbb{R}^d \) represents the measurable interference vector [17]. The commonly used form of the model is convolution model, including step response model and impulse response model. The model has its own integrator convolution model, state space model, and Volterra model.

3. Formula (3) is the output constraint, formula (4) is the control constraint, and formula (5) is the control gain constraint. Based on the predictive control principle, calculate all sampling times and solve the optimization problem. The results are as follows:

\[
\Delta U^*(k) = [\Delta u^*(k), \Delta u^*(k+1), \ldots, \Delta u^*(k+m-1)]^T.
\]

(8)
The control increment sequence \( \Delta U^* \) is used in the system, and \( \Delta U^* (k + 1) \) is calculated based on the new measurement results at the next sampling time.

3.4. Parallel Computing. Figure 3 shows the parallel computing architecture. The system is applicable to the relationship between the structures of multi-FPGA or DSP parallel computers. The common types of FPGA and DSP parallel computers are array machines, pipelined machines, and multiprocessor systems [7]. The pipelined technology is used to improve the speed of multiple parallel computing based on pipeline and data throughput. Similarly, the array machine is a kind of SIMD architecture (single input multiple data). Associative memory processor and systolic array machine were first proposed in the early 1980s. Its remarkable feature is that under the same control, a large number of PES are operated in parallel by synchronous locking mode to realize large-scale computing jobs. In the design of some array machines, the recursive operation, multiplication and addition calculation, and matrix multiplication operation often used in digital signal processing become multiple PES, and then, all PES are connected according to a certain law, so as to quickly improve the calculation speed.

4. Optimal Layout Model of Music and Cultural Facilities

Music culture has become an emerging industry under the environment of rapid development of cultural undertakings and economy, and finally become a brand-new music culture industry. Music culture facilities are the main material space carrier of music culture, which enriches the industrial content and realizes the expansion of industrial linkage [18]. As an emerging industry, the rapid development of music culture industry should be combined with the ways of industrial development and diversified binding with coordinated development, so as to increase the industrial share in the market and strengthen industrial publicity. We upgrade the traditional music culture and form an industry, so as to show the development space and importance of music culture. There is a direct relationship between music cultural value and social benefits, and industrial value is related to the development of economic benefits. It can be seen that music culture and industry complement each other and develop together. The rapid development of music culture industry has a certain driving effect on the cultural development and economic improvement of the region, and will also develop into a pillar industry in a certain region.

4.1. Composition Type of Music and Cultural Facilities. Based on the groups and functions of urban music and cultural facilities, this paper redivides them into several types. The common types of music and cultural facilities are (i) recreation, (ii) education, (iii) community, (iv) performance, and (v) commerce. The educational type mainly includes training institutions, piano companies, schools, etc. The recreational types mainly include gardening, fountains, streets, etc. Similarly, the performances mainly include theatres, concert halls, clubs, and opera courts, and the community type mainly includes cultural stations and activity centers. The commercial type mainly includes hotels,
bars, and KTV. Further details of the composition types are shown in Table 1.

4.2. Equity Model of Music Cultural Facilities. In the process of studying the space of music and cultural facilities, the most important thing is to analyze the relationship between citizens and facilities. The difference and connection between them are expressed according to the spatial distance. The characteristic results are very objective. On this basis, the layout of music and cultural facilities is analyzed from the needs of both sides and the factors affecting the spatial distribution. From the perspective of practical users, the distance between the arranged music culture settings and consumers is short. This means that the time for customers to arrive at music culture facilities is short, and the satisfaction is higher.

Lorentz curve is a kind of “fairness curve” in statistics. Usually, the “Lorentz curve” is used to express the fairness between the capital allocation and social income. This calculation can objectively judge whether a country’s income allocation is balanced or not. Based on different types of social regions and strata, the capital or income is divided into multiple levels, which are arranged and superimposed in order, according to the size of the share. It is expressed on the ordinate, and the abscissa is the superimposed population. Based on this, the points are connected to form a Lorentz curve (as shown in Figure 4). The broken line with an angle of 45° is selected as the average line. If there is an unfair phenomenon, there will be a prominent radian on the Lorentz curve. Generally, the arc below the fair line is a Lorentz curve, which shows a relatively tortuous curve on the abscissa. According to the radian size, it indicates the proximity between the configuration and the average value. If the arc is large, it indicates that the configuration is seriously unbalanced. Figure 4 demonstrates the schematic diagram of the Lorentz curve.

4.3. Attraction Model of Music Cultural Facilities. Lagrange extended the law of universal gravitation and put forward the concept of gravitational potential. In the early 1950s, scholars in the social and economic fields believed that the connection between regions and cities was attractive based on this concept. From the perspective of urban facilities, the vast majority of facilities have strong attraction to...
practical users. After the basic needs of users are obtained, the attraction also reflects the attraction and aggregation of the relevant facilities. At present, the research on attraction focuses on reducing the transaction costs, flexible layout, and basic behavior of facility users. Note that \( i \) and \( j \) are two existing fixed points, and there is a positive correlation among the established relationship between the two points. This should be noted that the activity relationship of \( i \) indicates that the separation coefficient between the two places is a positive correlation, which is expressed by the following formula:

\[
A_{ij} \propto E_i \quad A \propto \frac{1}{f(t_{ij})}
\]  

(9)

The following conclusions can be drawn:

\[
A_{ij} = \frac{E_i}{d_{ij}} \quad i = 1, 2, 3, \ldots, j = 1, 2, 3, \ldots
\]  

(10)

In the above formula, \( A_{ij} \) represents the operation potential between location \( i \) and location \( j \); \( d_{ij} \) represents the time length or spatial distance between two locations \( i \) and \( j \); \( \beta \) represents the impedance coefficient; and \( E_i \) represents the operation level of location \( j \). Keeping these parameters in mind, then the total attraction of location \( i \) is calculated by the following formula:

\[
A_i = \sum_j A_{ij} = \sum_j \frac{E_j}{d_{ij}^\beta}
\]  

(11)

Based on this, the attraction formula is used in music and cultural facilities to calculate the attraction of the people affected by music and cultural facilities in a certain area. Note that \( E_i \) refers to the scale of building the \( i \)th music and cultural facility. Moreover, \( D \) represents the spatial relationship between the music and cultural facilities and citizens, usually taking the shortest distance between them. Similarly, \( P \) is the impedance coefficient, that is, dependent on the attraction—the higher the value of \( A_i \), the stronger the attraction and vice versa.

5. Application of Prediction Model Based on Parallel Computing in Music Cultural Facilities

5.1. Analysis on the Composition of Music and Cultural Facilities. When studying the applications of prediction model based on parallel computing in music cultural facilities, this paper selects Chongqing as the main research object for analysis. Based on the composition types of music and cultural facilities, suggested and proposed above, Chongqing music and cultural facilities are sorted out and divided into (i) recreation type, (ii) education type, (iii) performance type, (iv) commercial type, and (v) community type. According to the proportion of different types, the types of music and cultural facilities in Chongqing are mainly commercial and educational, accounting for a higher proportion compared with the three types of performance, recreation, and community. However, these three types are more similar to people’s life, which is conducive to establishing a good image of the music and culture in Chongqing district. According to the data, as shown in Figure 5, and its analysis, we observed that the types of music and cultural facilities in the Chongqing district are unevenly distributed and lack a certain number of public welfare and open music culture.

This paper investigates the music and cultural facilities in the main administrative regions of the Chongqing city. The results show that the administrative regions with large population have a large number of facilities. There are many educational facilities in the Jiangbei district, but the allocation of other types of facilities is uneven. Moreover, the distribution of music and cultural facilities in Yuzhong district is relatively balanced. Because the area has complete large-scale music and cultural facilities and performance facilities, therefore, it can meet various basic needs of holding concerts. After analysis, it is concluded that in the market-free leading environment, music and cultural facilities will be deployed with commercial and educational facilities, and the line environment with certain optimization measures will redistribute the system on the basis of configuration, which will greatly improve the quality and efficiency of facilities [19, 20]. The actual distribution of music and cultural facilities in each district of the Chongqing is shown in Figure 6.

5.2. Equity Analysis of Music Cultural Facilities. When analyzing the fairness of music and cultural facilities, this paper first obtains the proportion of the total population of each region and the proportion of music and cultural facilities in the total amount of the city. In the second step, this arranges all data from small to large scale according to the proportion data of the music and cultural facilities built in each street. In the third step, we draw the Lorentz curve of the proportion of population and music and cultural facilities, as shown in Figure 7. The Lorentz curve of the cumulative value of the proportion of population in each district of Chongqing, and the ordinate is the cumulative value of the proportion of music and cultural facilities built in each district of the Chongqing city. Next, we draw the Lorentz curve of the music and cultural facilities in Chongqing according to the population distribution according to the data. Based on the above data, the Gini equity coefficient, of the music and cultural facilities in each region of the Chongqing according to population distribution, is 0.53.

The Lorentz curve of music and cultural facilities drawn based on the population proportion in Figure 7 above can be obtained through comprehensive analysis of the Gini coefficient. The Gini coefficient of music and cultural facilities accumulated in Chongqing based on the population proportion is 0.53, indicating that Chongqing has serious unfair problems in the construction of music and cultural facilities in various districts, especially in the construction of fewer music and cultural facilities, with a large gap [21–23]. This shows that the music and cultural facilities built in Chongqing are seriously unbalanced.
At the same time, only four districts in the central urban area of Chongqing have built large-scale music and cultural facilities, and no music and cultural facilities have been built in other districts [24]. Therefore, in order to strengthen and improve the service capacity of music and cultural facilities in Chongqing, we must first invest a lot of money in services of music and cultural facilities to improve the resource level of music and cultural facilities as a whole; in addition, we should also talk about the balanced distribution of resources of music and cultural facilities in each region, reduce the imbalance, and make services of the music and cultural facilities between each region relatively fair [25].

5.3. Analysis on the Attraction of Music Cultural Facilities. A main part of the analysis of the spatial layout of facilities is to analyze the attraction of music and cultural facilities. This paper uses the attraction model to reflect the demand and service level of music and cultural facilities, and intuitively shows that the service capacity provided to music and cultural facilities is further weakened with the extension of citizens’ travel time, which usually shows a state of continuous decline. Here, Harvard model is selected as the attraction calculation model of music and cultural facilities, and the expected time of citizens to music and cultural facilities is calculated based on urban road traffic. According to the predetermined visits of music and cultural facilities, the service level and attraction of music and cultural facilities can be quantified, so as to accurately reflect the service capacity of music and cultural facilities, and the blind spots and problems existing in the layout of music and cultural facilities can be fully reflected in the objective calculation results. Based on the combination of current urban roads, traffic resistance, and the time of music and cultural facilities, five minutes is selected as the basic time to study the expected visits of music and cultural facilities [26]. The following is the basic calculation formula:

\[
E_i = \sum_{j=1}^{m} \frac{S_j C_i}{D_{ij} \sum_{j=1}^{n} S_j/D_{ij}}
\]

(12)

In the above formula, \(S_j\) represents the area of the block \(j\), and \(D_{ij}\) is the distance between the music and cultural facilities \(i\) and \(j\) roads, \(\lambda\) represents the resistance coefficient, which is approximately 1.5; \(C_i\) is the specific number of people arriving at the music facility \(i\); \(m\) represents the number of accessible areas; and \(n\) represents the number of music and cultural facilities. The pre-access rate \(D_i\) can be calculated by the following formula:

\[
D_i = \frac{E_i}{p}
\]

(13)

In the above formula (13), \(D_i\) represents the previsit rate, \(p\) represents the total number of people in the region, and \(E_i\) represents the previsit volume. The above formula shows that the relationship between the attraction of music and cultural facilities and the accessible area is positive, and it is also positive with the number of people in the region, but inversely proportional to the travel time [27]. In this way, the
public transport mode.

...and analyzes the composition types of music cultural facilities, and establishes the optimal layout model of music cultural facilities, this paper summarizes the basic principle of model predictive control and parallel computing process, through applying the prediction model based on parallel computing in music scientificity and preciseness of music culture. Through applying the prediction model based on parallel computing in music cultural facilities, this paper summarizes the basic principle of model predictive control and parallel computing process, establishes the optimal layout model of music cultural facilities, and analyzes the composition types of music cultural facilities.

Taking Chongqing as the main research object, this paper analyzes the allocation of music and cultural facilities in various districts of Chongqing, lists the types and specific quantities of music and cultural facilities in various districts, analyzes the fairness and attraction of music and cultural facilities equipped in different regions, draws the Lorentz curve of music and cultural facilities based on the proportion of population, and comes to the conclusion that the Gini coefficient of music and cultural facilities in Chongqing is 0.53. In the future, we will consider other parallel computing, prediction models, and artificial intelligence techniques to investigate the topic well. Moreover, the more data should be used to generalize the outcomes of this research. Other evaluation metrics should be used to evaluate the performance of the proposed prediction model. In the meanwhile, prediction methods are usually dependent on a dataset, and model training might take a long time if the dataset is vast. To lessen the amount of time it takes to train the model, we will look at adopting aggregation approaches or more robust parallel computing enabled prediction algorithms.

### Data Availability

Data are available on request from the corresponding author.

### Conflicts of Interest

The authors declare that they have no conflicts of interest for publication of this work.

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