Music-Driven Emotion Model Applied in Digitalized Dance Performance of Sacrificial Ceremony for Confucius

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Abstract. The sacrificial ceremony for Confucius is one of the most important Chinese cultural heritages which could be protected by means of digital technology. A digitalized system, which was developed to reconstruct the musical dance performance of the ceremony, includes music analysis based on emotion model and action movement library based on a virtual model for the choreography with the motion capture technique, and the action correlation with music-dance match. The simulation results of the digitalized dance performance of the ceremony shows that the system allows people to make a better understanding of the cultural evolution.

Keywords: Emotion model, digitalized cultural heritage, sacrificial ceremony for Confucius.

1 Introduction

Musical dance performances are the heart of the sacrificial ceremony for Confucius, which was an ancient ritual to commemorate Confucius's birthday. This ceremony, which was called as *national ceremony*, had been paid more and more attention by Ancient Chinese Emperors since it firstly held in 478 B.C. and perfectly demonstrate the traditional Chinese culture.

Kallmann [1] presents a feature modeling approach to define behavioral information, paying special attention to the capabilities of interaction. Sheng [2] designed a Motion Compilation System in Bianzhong Choreography, and a methodology is presented to achieve the motion connection by analyzing the characteristic action unit and related restriction. As early as in 1996, Goto and Muraoka [3] implemented a virtual dancer "*Cindy"* which can dance in rhythm to musicians' playing. Kovar and Gleicher [4] constructed a directed graph called a *motion graph* for creating realistic, controllable motion, and the general framework they presented can be applied to the specific problem of generating different styles of locomotion along arbitrary paths. Mori and Ohta [5] realized the virtual hip-hop performance which allows users to determine the action sequences sets and builds

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relationships between music and movement characteristics. Reidsma and Nijholt [6] designed a virtual rap actor that can dance with music rhythm.

To reconstruct the musical dance performance of the sacrificial ceremony for Confucius, we firstly collected dance movement data so as to build a music-driven digitalized dance animation system based on emotion model. Then, we created three-dimensional human body models with the synthesis of a certain amount of features on the dance unit and judged actions related and music action match degrees. In the end, through simulation platform within the emotional characteristics of dance and music, the intangible cultural heritage found its new space in the contemporary evolution under the conditions of full development in the new era.

2 System Framework

This music-driven dance system relies on four core modules: action movement library module, music emotion analysis module, action choreography module, and music and dance output module, which is shown in Figure 1. The action movement library includes the model setting of figures and the basic dance movements of dance performance. The music emotion analysis module includes the correlation analysis of music and music emotion matched to music. The action choreography module combines music emotion and dance movements by analyzing the dance grammar to establish a network action unit. The last module is based on the former work and makes a comprehensive analysis to the emotional characteristics of dance and music. It also determines to what extent the emotional attributes of music and dance can match each other.

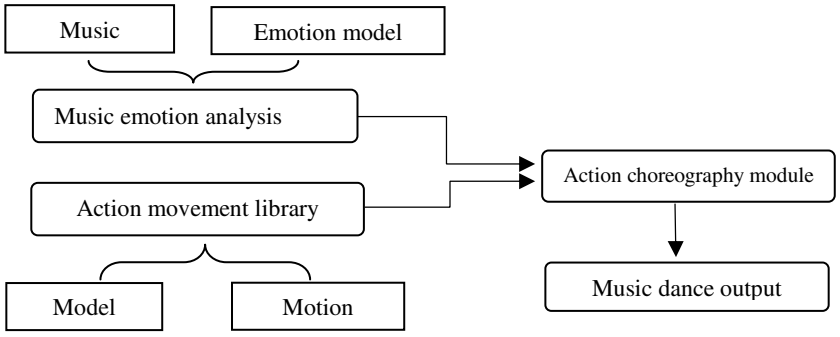

Fig. 1. Music-driven emotion model dance system framework

3 Music Emotion Analysis

To analyze the rhythm of the music, we selected the representative music fragment in dance performance of sacrificial ceremony for Confucius for rhythm resolve. The staff notation and the parsed rhythm are shown in Figure 2 and Figure 3.

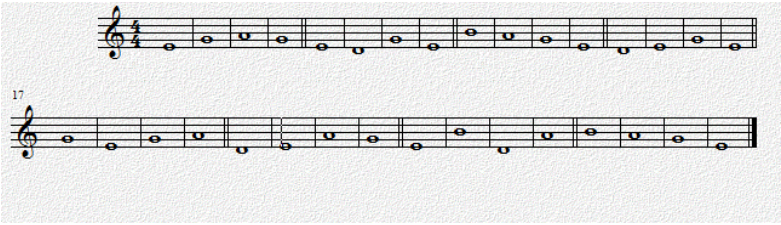

Fig. 2. The staff notation of the music fragment

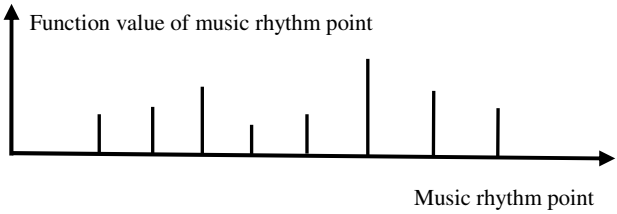

Fig. 3. The parsed rhythm of the music fragment

We choose the Hevner affective ring [6] as emotion model. Hevner affective ring, which is shown in Figure 4, was utilized to fully express the emotional content of music. As a psychological model of the emotional content of music, Hevner affective ring is widely used complying with the connotation of music emotion inherent laws. But Hevner's research aims at the West group. After all, the emotional sub-classes in the vocabulary are not necessarily consistent with China's real situation. Therefore, in this paper, the emotional expression model is based on the ring, but not the same. As picking out eight emotion adjectives groups which are appropriate for the ceremony music, our Emotional Expression Model is shown in Table 1. Also, each type of the Model is a representative of one-eighth of the region in Hevner affective ring.

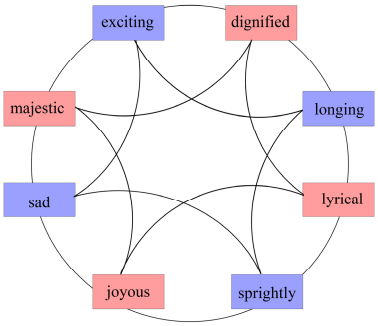

Fig. 4. Hevner affective ring[6]

Table 1. Emotional Expression Model

Category	Example
Dignified	Awe-inspiring Sober
Longing	Longing Tender
Lyrical	Lyrical Leisurely
Sprightly	Graceful Light
Joyous	Bright Joyous
Sad	Heavy Mournful
Majestic	Exalting Majestic
Exciting	Passionate Agitated

4 Action Movement Library

By means of bone skin animation technology, a single dancer role consists of a single skin mesh and bones. Every vertex of the skin is under the influence of one or more bones. We can get the vertices in the correct location in the coordinate system of the world by weighting each bone for its impact on the vertices and then follow the skin mesh and the corresponding weight information.

Through previous collections such as writing records, shoot pictures and videos, we get numerous materials for choreography. Dance movements using motion capture equipment can be recorded. After getting the dance motion data, a dancer character model was established, as shown in Figure 5.

In order to get available processing data, performers are required to put on a one-color, tight-fitting clothes. At key parts of the body, such as joints, hip, elbow, wrist, we will post some of special Marker on them, as shown in Figure 6.

Fig. 5. A dancer character model

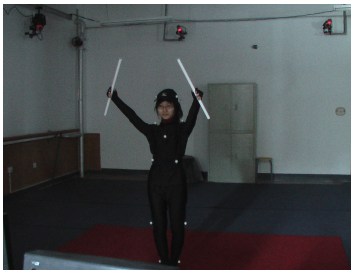

Fig. 6. Distribution of markers in motion capture

5 Action Choreography

After building music and dance movement database, we classify the movement styles based on emotion model, identify dance styles, summarize the characteristics of each move unit, and conduct further research about the movement association.

In order to make a division of joint action about the signature style of action units in the physical layer characteristics, a motion equation can be expressed as:

$$Fi = (\Sigma Ai \,\&\, \Sigma Bi \,\&\, \Sigma Ci \,\&\, \Sigma Di) \quad (1)$$

Where Fi means the whole body, ΣAi, ΣBi, ΣCi, ΣDi are four major joint actions, ΣAi refers to head movements, ΣBi refers to trunk movements, ΣCi refers to arm movements, ΣDi refers to the lower limbs. In each category of the style actions, according to the frequency of joints of the body unit, we define the priority factor and determine the optimal solution of the choreography, close to the mark action.

5.1 Action Correlation Analysis

Because of different dance directors, the sacrificial dances will have their own characteristics and styles. However, there are strict standards of sacrificial music and dance. Dancers must observe certain rules and procedures. Dancers' steps, postures, direction and cycles are clearly defined.

If the joints group occurs without meeting the dance aesthetics and logic principles of relative restriction, it must be discarded. Figure 7 shows the movements which are head to left & body left sideways & stretch right hand & reach out right foot, then the following movements are head to right & body right sideways & stretch left hand & reach out left foot, as shown in Figure 8. Considering about aesthetics and logic aspects, movements like bow & body sideways & cross hand & right foot should be avoided, as shown in figure 9.

Fig. 7. Proper movements

Fig. 8. Following movements

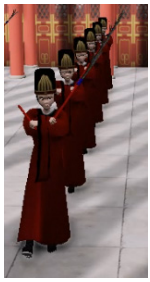

Fig. 9. Improper movements

5.2 Music and Action Matching

The key point of music-driven dance is how to calculate the matching degree between the bottom of the extraction music physical characteristics and the rhythm of the dance movement characteristics. Here we use dynamic time warping (DTW) to measure the matching degree. Based on dynamic programming, DTW combines the time warping and distance computational measure to find a calculation method which has the shortest distance between two vectors.

By means of DTW algorithm, and the action of a given music unit series, we can combine the best match actions with a music feature point path. For any random

action music clips combination (R, T), R is the action characteristic vector sequence and T is the music characteristic vector sequence. R and T are defined as:

$$R = \{R(1), R(2), \ldots, R(M)\}, \qquad T = \{\{T(1), T(2), \ldots, T(N)\} \tag{2}$$

Where M is the total frame of action model and N is the total frame of music model.

The computation formula for the accumulating distance is as follows:

$$\lambda(j, k) = d(j, k) + \min\{\lambda(j-1, k-1), \lambda(j-1, k), \lambda(j, k-1)\} \quad (1 \leq j \leq M, 1 \leq K \leq N) \tag{3}$$

Where d (j, k) is Euclidean distance between T(j) and R(k). The smaller the Euclidean distance is, the smaller the distortion is, and hence the greater the similarity will be. Through the recursive type we can calculate the matching degree [7].

6 Questionnaire

There are many ways of user experience experimental testing. We have taken a laboratory test method which combine the questionnaire and sound thinking. Sound thinking method is also called the sound thinking test. People to be tested need to incessantly express their own opinion during operating system and express their inner thought. This method has the advantage of stable flexible and low cost. In the interactive user experiment of Confucius memorial ceremony, we guide the user timely and encourage them to express their inner feelings and problem while doing the experience process. We listen to the outward users and induce the endoscopic user to communicate and capture the user's actions and the emotions through words in time.

In order to evaluate and test our approach, 10 undergraduate students are invited to do the user experience research. They all passed the music sensitivity test which proves that they have good music sensitivity. After watching the combination of action-music clips, each participant was required to fill in the questions as listed in the table 2, the category of questions in the questionnaire scores on the satisfaction of the two experiences. 5 points stands for very satisfied, 4 for satisfied, 3 for generally, 2 for not satisfied, 1 for very dissatisfied with.

Table 2. Users' satisfaction results of Confucius memorial ceremony animation

animation	Overall experience	Reality	Easy	Natural	Fun	Flexible
average	3.7	3.5	3.9	3.5	3.2	3.1
N	10	10	10	10	10	10
standard deviation	0.82327	0.52705	1.19722	0.70711	0.91894	1.28668
animation	Attractive	Culture understand	Cultural entertainment	Cultural learning	Initiative participate	
average	3.2	4.1	3	3.7	2.8	
N	10	10	10	10	10	
standard deviation	0.91894	0.56765	0.94281	1.1595	1.0328	

In addition to the questionnaire quantitative study, we also get some valuable opinions from participants. Some have proposed that we should add more mark actions, in order to compile various kinds of dance. Some participants suggested that we can elaborate the dance from the aesthetic view. Moreover, some users proposed that we should create a rich interaction so that people could dance with virtual dancers which mean the synchronization between them.

7 Conclusions and Future Work

In this paper, we developed a music-driven system to digitalize the musical dance of sacrificial ceremony for Confucius. In this system we analyze the music based on Hevner affective ring emotion model, use motion capture technology to build the action movement library and accomplish the digital production through the action choreography. This system to achieve the fit of music and dances in the ceremony for Confucius, and has reference value in how to complete preservation of traditional culture and heritage. Meanwhile, it has further exploration in music-driven dance choreography and interactive aspect between watcher and system on the basis of digital recovery and performance.

However, our work considered relatively limited. It is a really complex problem to measure the matching degree between action and music. One possible solution is to use an autonomic machine learning model, which can get the music connection rules from large scale sample database within the global harmony consideration.

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