Computer-Aided Design AND APPLICATIONS

Dance Movement Design Based on Computer Three-dimensional Auxiliary System

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Abstract. The Marching Cube method, a classical algorithm based on the voxel method, is used to perform three-dimensional computer-aided dance movements. Aiming at several problems in the MC algorithm, an optimization and improvement method is proposed, which realizes the organic combination of image segmentation and the MC algorithm. We use the segmented binary data to extract the isosurface; solve the ambiguity problem by establishing a look-up table of intersection conditions; use the method of quickly finding the boundary cube to avoid searching for a certain amount of empty cells; at the same time, use the midpoint method to calculate the triangle vertices. This paper verifies the effectiveness of the dance action recognition algorithm proposed in this paper on the dance data set DanceDB of the University of Cyprus and the folk dance data set FolkDance produced by the laboratory. The experimental results show that the algorithm in this paper can maintain a certain recognition rate for more complex dance movements, and the method in this paper can still guarantee a certain accuracy rate when the background and the target are easily confused. This also verifies the effectiveness of the motion recognition algorithm in this paper for dance motion recognition.

Keywords: dance movement design; computer three-dimensional assistance; dance feature fusion; MC algorithm
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1 INTRODUCTION

The art of dance is known as the mother of art. With the progress of society, the art of dance is constantly developing and evolving. The art of dance has the characteristics of rhythm. It expresses its inner rhythm through the changes of various rhythms, and brings different inner feelings to the viewer and the dancer; the art of dance has dynamic characteristics [1]. Dance uses the dancer to twist the torso and limbs. To make different movements, dance art has a strong lyrical characteristic, dance is the most intuitive and the most intense way of expression of emotions [2]. The emotional changes and the speed of the movements can also reflect the intensity of the inner feelings; the various characteristics of dance art determine that it has become a favorite entertainment method for people [3]. Each movement has a corresponding flow before and after the movement, and each footwork has strict requirements, which brings a huge cognitive load to the learning and entertainment of ordinary users. It takes a long time and a lot of energy to learn peacock dance, which runs counter to the original intention of learning to entertain. Therefore, reducing the cognitive load of learning in the dance entertainment process is the voice of the majority of users, and it is also a place where designers should pay attention to and improve in dance entertainment system design and educators in dance teaching [4].

This paper studies the three-dimensional computer-aided technology based on voxel method, and introduces the principle and idea of MC algorithm, the representative algorithm in voxel method. Aiming at the shortcomings and existing problems of this algorithm, optimization and improvement are carried out, and an improved three-dimensional computer-aided algorithm based on the classic MC algorithm is proposed. It organically combines image segmentation with the MC algorithm, and uses the segmentation results to extract iso-surfaces more accurately, avoiding the limitation that the MC algorithm is only suitable for threshold segmentation; using the intersection state look-up table to solve the ambiguity problem and make the topological structure consistent, we adopt the interlaced retrieval method to improve the efficiency of finding the boundary cube; at the same time, we use the midpoint method to calculate the vertices of the triangle to reduce the amount of calculation. In the experimental link, the dance data set used and the dance data set are introduced in detail. Finally, the control method and all the features involved in this article are tested on two dance data sets respectively, and the effectiveness of the method of this article is verified by comparison based on the experimental results.

2 RELATED WORK

Islamoglu and Deger [5] believe that action classification needs to follow and conform to the mainstream trend of the current technological development of the project. It is emphasized that the classification of actions depends on the consistency of the basic technology and the main technical links contained in the action, rather than being limited to the classification of actions based on the similarity of the external morphological features described or presented by the action. Similarly, in the classification of jumps in figure skating, scientific classification is also carried out according to the difference in take-off techniques, especially in rhythmic gymnastics. Gale had proposed user-centered design methods and principles [6]. And seven specific design principles are given. At the same time, the user experience is divided into instinct, behavior and reflection levels, emphasizing the importance of emotion in user experience. And it analyzed in detail how to incorporate emotion into the design.

Juliff and Early [7] pointed out that the current new media dance entertainment mainly includes dance games on mobile devices, dance machines and dance games on somatosensory device platforms. Because dancing games and dancing machines require additional auxiliary equipment and only partial body operation and interaction, they cannot achieve the natural interaction of dance entertainment. Somatosensory dance entertainment adopts somatosensory motion detection equipment, and the interactive mode conforms to the characteristics of dance entertainment. However, not all the design of motion recognition and interactive operation can make users feel simple, smooth, and natural.

With the continuous evolution of dance types and forms, and the continuous increase of dance videos, how to browse dance videos quickly and effectively is the main problem now facing. Patrizi et al. [8] believe that the movements of music and dance videos are complex and changeable, and the problem of multiple repetitive movements has brought troubles to the analysis and recognition of dance movements. Therefore, in order to increase the rate of dance video analysis and reduce the computational complexity, extracting the key frames of the music dance video will be an effective solution. Key frames are defined as some representative image frames with less redundancy in the video. For dance videos, key frame extraction is a process of removing redundancy. At a certain moment, the music is expressive, and there is a big difference between the current frame and the previous key frame, then the image frame is regarded as the new key. Leonard et al. [9] pointed out that through key frame collection, users can quickly understand the content of dance videos, which not only shortens the time for users to browse dance videos, but also saves video storage space.

The classification system of movements is of great significance to the improvement of the theory of difficult-to-beauty items in the skill-oriented category. As far as rhythmic gymnastics is concerned, the research on the classification of physical difficulty movements in rhythmic gymnastics is the basis for improving the technical level of physical difficulty movements. In the aerobics project, the study of movement classification is of great significance to perfect the aerobics theory system and promote the teaching, training and competition of aerobics. There are many difficulties in researching and training such complicated and diverse movements. Therefore, scientific classification can be more effective for research and training. At present, standard dance teaching in colleges and universities generally adopts a single-combination teaching based on the progressive combination of difficulty levels. The teaching content is systematic, but it can solve the three major problems of students' dance physical ability, dance technical skills, and style training. Ruiters et al. [10] pointed out that a reasonable classification and grading system of standard dance movements can solve the urgent task of how to enable students to effectively and quickly master technical movements in teaching, promote the horizontal induction of core techniques, and improve the need for theoretical research on standard dance techniques.

3 3D SURFACE COMPUTER-AIDED TECHNOLOGY BASED ON VOXEL METHOD

3.1 Three-Dimensional Computer-Aided Method Based on MC Algorithm

Among the methods of constructing iso-surfaces for surface rendering, the most representative one is the Marching Cube method, referred to as the MC method. The three-dimensional images it generates are relatively clear and can replace the physical model to a certain extent; hardware acceleration functions can also be applied, and the drawing speed is fast. The three-dimensional computer-aided method in this article is the MC method. Here is an introduction to the principle of the MC algorithm, so as to achieve faster and better three-dimensional computer assistance.

In the MC algorithm, in order to construct an iso-surface in a three-dimensional data field, the value of the spatial data field element (pixel) where the iso-surface is located must first be given, that is, the threshold. The MC method finds the position of the cube passed by the equivalent surface in the data field. Figure 1 shows a schematic diagram of reading and displaying dance movements.

When the edge of the boundary cube is parallel to the X axis, we set the two end points of the edge to v1 (i, j, k), v2 (i + 1, j, k), the critical threshold is c, then the intersection point is v(x, j , k), where:

$$x = i - \left| f(v_1) - c \right| / \left[f(v_1) + f(v_2) \right] \tag{1}$$

When the edge of the boundary cube is parallel to the Y axis, set the two end points of the edge to v1, (i, j, k), v2 (i, j + 1, k), the critical threshold is c, then the intersection point is v(i, y, k), where:

$$y = j - \left| c - f(v_1) \right| / \left[f(v_1) + f(v_2) \right] \tag{2}$$

When the edge of the boundary cube is parallel to the Z axis, set the two ends of the edge to v1(i, j, k), v2 (i, j, k + 1), the critical threshold is c, and the intersection point is v(i, j , z), where:

$$z = k - \left| f(v_1) - c \right| / \left[f(v_1) + f(v_2) \right] \tag{3}$$

You can connect these intersection points into triangles according to the triangulation method determined by the index table to obtain the iso-surface in the cube. First, we calculate the normal vectors at the 8 vertices of each boundary cube by the central difference method.

$$N_u = G_u \bullet \left[(G_x)^2 - (G_y)^2 - (G_z)^2 \right]^{-1/2} \tag{4}$$

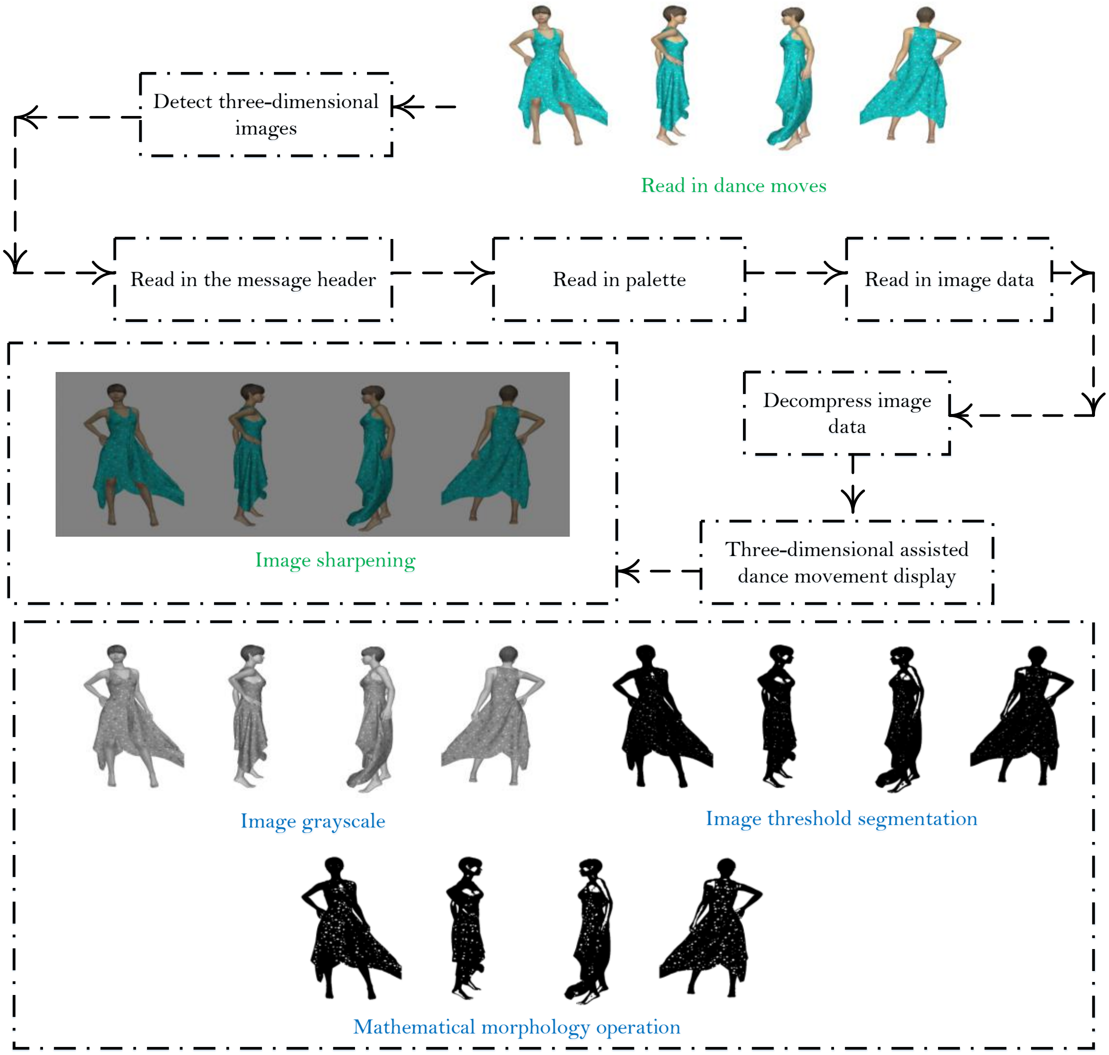

Figure 1: Schematic diagram of reading and displaying dance movements.

Among them:

$$G_x = g(i, j+1, k-1) - g(i, j-1, k-1) \tag{5}$$

$$G_y = g(i-1, j+1, k) - g(i, j, k-1) \tag{6}$$

$$G_z = g(i-1, j-1, k-1) - g(i-1, j, k-2) \tag{7}$$

Linear interpolation is used to calculate the normal vector of the intersection point. The formula is as follows:

$$N = N_1 - \frac{1}{V_1 - V_2} \bullet |V_1 - c| \bullet |N_1 - N_2| \tag{8}$$

Among them, N represents the normal vector, N1 and N2 represent the normal vector of the two endpoints, and c represents the critical threshold.

3.2 Optimization and Improvement of Computer 3D-Assisted MC Algorithm

The improved algorithm in this article first segmented the original data field to obtain binary data (255 represents the background, 0 represents the object that needs computer assistance), and then uses it to construct a three-dimensional iso-surface. Due to the combination of segmentation and MC, it gets rid of the limitation that standard MC can only use threshold segmentation. Using the segmented binary data as input, the MC algorithm can more accurately computer-assisted the three-dimensional model of the target object. The input data adopts both input divided binary data and original picture data. The segmented binary data is used for surface tracking to determine the boundary cube and triangulation method, and the original data is used to calculate the normal vector of the iso-surface, which can ensure that the computer-aided effect is relatively smooth. The final output of the three-dimensional model is represented by an array of triangles.

Regarding the calculation of the intersection of the iso-surface and the cube, this paper takes the midpoint of the edge of the cube as the intersection of the iso-surface and the edge of the cube. This is mainly based on two considerations: First, the image is binary, and there is no need to enter a specific threshold to intersect; on the other hand, in standard MC, a cube with an iso-surface is likely to have multiple triangles. In this way, each triangle is very small, even smaller than the pixel, so the change caused by replacing the vertex with the midpoint has little effect on the final image quality.

Through the analysis of the classic MC algorithm, this article has achieved several optimizations and improvements, including the use of more accurate three-dimensional computer assistance based on segmented binary data. The method improves the efficiency of retrieving the boundary cube; at the same time, the midpoint method is used to calculate the triangle vertices to reduce the amount of calculation. The specific flow chart of the improved algorithm is shown in Figure 2.

4 EXPERIMENT AND RESULT ANALYSIS

4.1 Dance Data Set

Since the current research on the combination of motion recognition technology and dance has just started, there are still relatively few dance data sets available. The publicly available is the motion capture data set of Carnegie Mellon University, but the dance data contained in this data set is very small; the DanceDB dance data set published by the Virtual Reality Laboratory of the University of Cyprus can meet the requirements of dance movement recognition research.

1) DanceDB

The currently open DanceDB dance data set of the University of Cyprus Virtual Reality Laboratory has 48 dance videos. The background and camera angle of view in each dance video are fixed. The frame rate of the image is 25fps, and the size of each frame is 460*280. Although the data set currently contains relatively few types, there are challenges in the video, such as moving targets and backgrounds that are easily mixed. It is about the relatively excellent dance movement data set disclosed in the field of dance movement analysis and research, so it can be used to measure the proposal presented in this article. There are 12 types of dance movements in the DanceDB dance data set, each of which uses an emotion label to mark it as a category of dance movements.

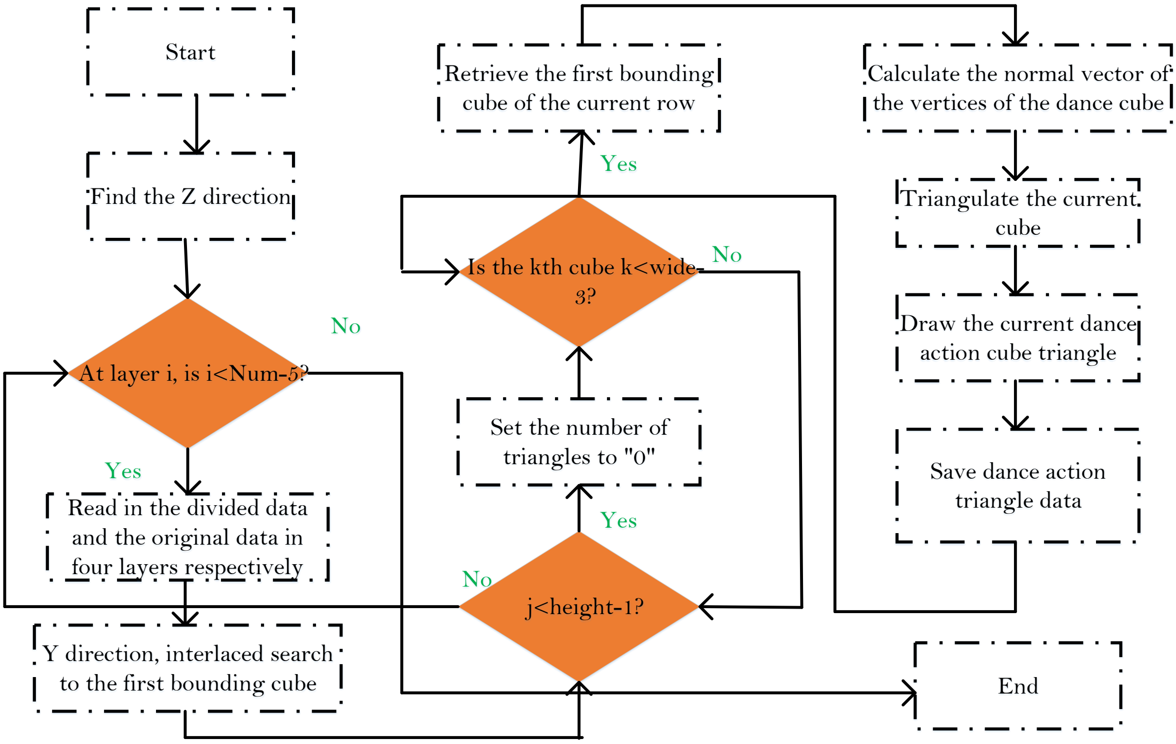

Figure 2: The overall flow chart of the improved MC algorithm

2) FolkDance

The FolkDance dance data set is a dance data set produced by the laboratory. The motion capture device Vicon is used to collect professional dance action videos. During the process of making the entire data set, the final plan is the design four according to the data set production plan and the discussion with dance experts. Given that the research on dance movement recognition is still in its infancy, the production of the FolkDance dataset currently only considers single-person dances, and does not consider factors such as changing stage backgrounds and props. During the specific dance video collection process, we invited a number of dance majors to perform dance performances according to group settings, and at the same time use Vicon equipment to collect dance video data. In the end, a total of 84 dance videos were recorded, and the background and camera angle of view in each video were set to be fixed. The frame rate of the image in the video is set to 20fps uniformly, and the size of each frame is 460*320. The data set contains many types of dance movements, and the dance movements are complex, which is more challenging for dance movement recognition. Therefore, it is more in line with the requirements of our research on dance video action recognition.

4.2 Evaluation Criteria

(1) You divide the data set into K groups, select one of them as the test set, and the remaining K-1 groups as the training set, repeat the cross-validation K times, and select one group as the

test set each time. Finally, the recognition accuracy rate of K times is passed through the average cross-validation as the final recognition result. Usually in the experiment, the value of K is generally selected as 10.

(2) The idea of the leave-one-out cross-validation method is to select a data set containing N samples as the test set each time. Leave-one-out cross-validation is actually a special case of K-fold cross-validation. In each test, almost all data set samples are used as training sets to train the model. Therefore, the results obtained by leave-one-out cross-validation are usually more reliable. The disadvantage is that when the data set is relatively large, the amount of calculation will increase and the time to train the model will also increase.

4.3 Results and Analysis

First, the comparison of the recognition results of the HOG feature extracted from the image produced by the accumulative edge feature algorithm in this paper and the original dance action image on the data set is given. Figure 3 shows the comparison of the two kinds of HOG feature recognition results on the FolkDance dataset.

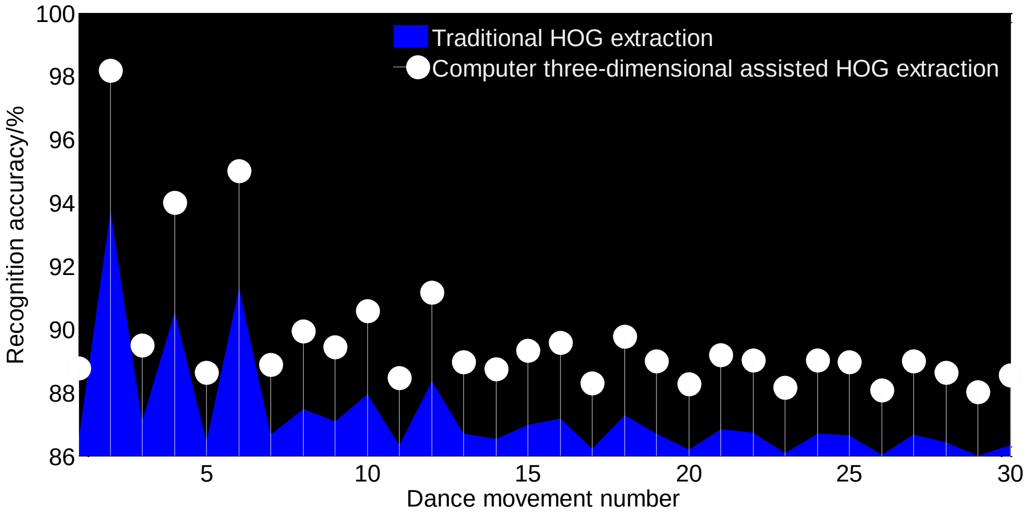

Figure 3: Comparison of experimental results of two HOG extractions on the FolkDance dataset.

The experimental results in Figure 3 show that the HOG feature recognition result extracted from the cumulative edge feature image generated by the cumulative edge feature algorithm proposed in this paper is better than the traditional recognition result of the HOG feature extracted on the original dance image. It is more effective to describe the shape of dance movements after accumulating the edge features. At the same time, considering the situation of the FolkDance data set, the dance moves of the first two groups have low similarity, and the dance moves of the latter two groups are more similar. This will have an impact on the recognition of the features used to describe the shape of dance movements. It can be seen from the experimental results that the recognition accuracy of the HOG features extracted by the two methods in the first two groups is higher than that in the latter two groups. The HOG extracted in this paper performs better than the HOG features extracted on the original image in the latter two groups. This shows that although the method used in this article is also affected by action similarity, the performance of the method used in this article is much less affected than the traditional method.

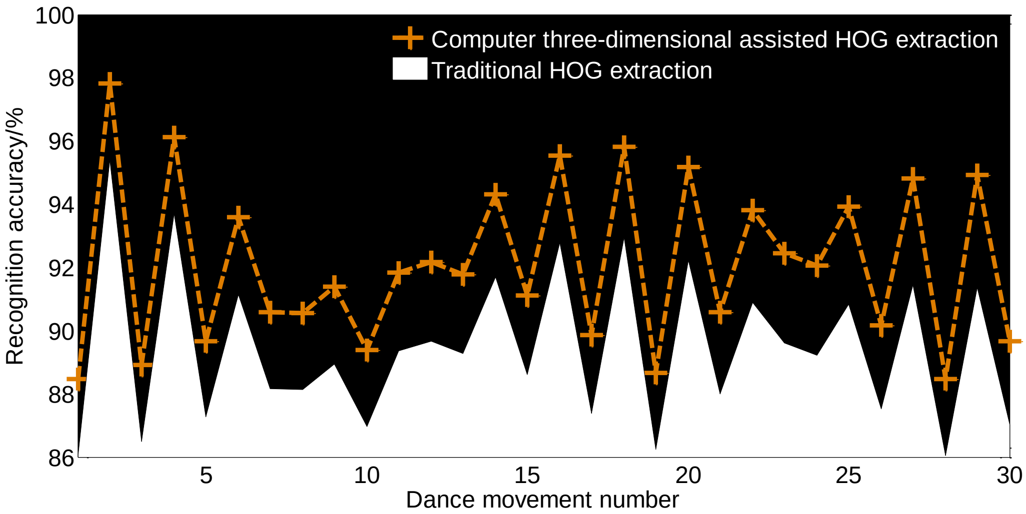

Figure 4: Comparison of experimental results of two HOG extractions on the DanceDB dataset.

Figure 4 shows the comparison of the recognition results of HOG feature extraction and traditional HOG feature extraction on the DanceDB dataset. In the DanceDB data set, there is a situation where the color of the moving target is similar to the background. The result in this article is higher than the traditional HOG recognition result. It can be seen that this article accumulates edge features and extracts HOG features on the generated images are less affected by the above situation than the HOG features extracted directly from dance images. The time-consuming experiment on the FolkDance dance dataset is shown in Figure 5.

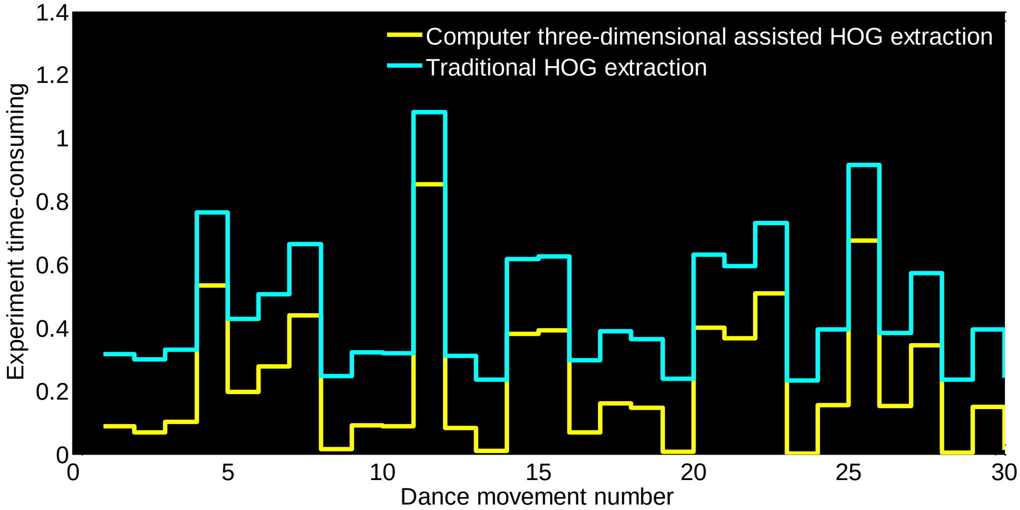

Figure 5: Experiment time-consuming on the FolkDance dance dataset.

In the four dance combinations in the FolkDance data set, the results of the comparison between the method in this paper and the benchmark method are shown in Figure 6. In the recognition of the four dance combinations, the recognition rate of the method in this paper is overall higher than that of the benchmark method.

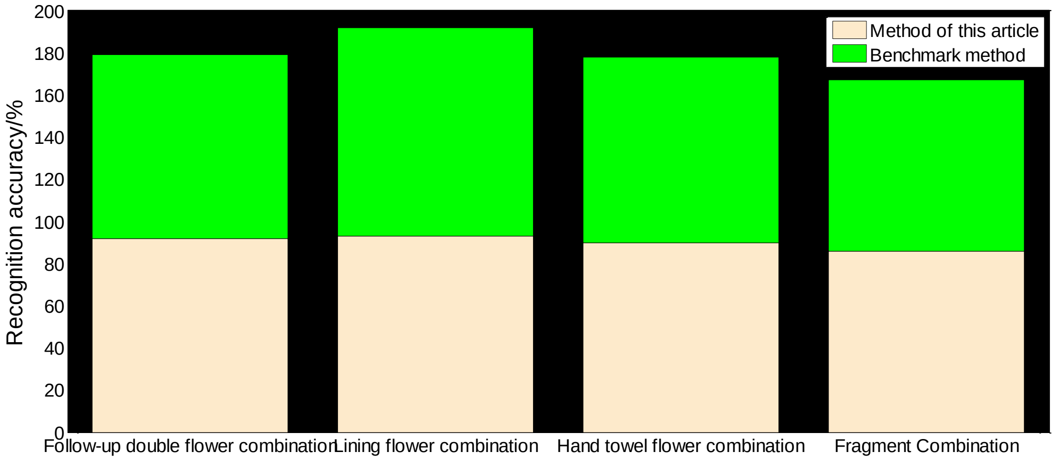

Figure 6: Comparison of experimental results between the method in this paper and the benchmark method in four groups.

The recognition rate of the method in this paper is 93.3% lower than the 98% of the benchmark method only in the liner flower combination. In other combinations, especially when the dance moves are too similar in the towel flower combination and the patch flower combination, the performance of the method in this paper is better than the recognition result of the benchmark method. This also shows that the trajectory features of the benchmark method based on trajectory feature fusion cannot accurately represent the dance actions when the dance moves are too complex and there are similar actions and self-occlusion. The fusion method proposed in this paper can avoid the above influence to a certain extent and improve the recognition rate of dance, so this also verifies the effectiveness of the algorithm in this paper. Figure 7 shows the time-consuming comparison of experiments on the DanceDB data set.

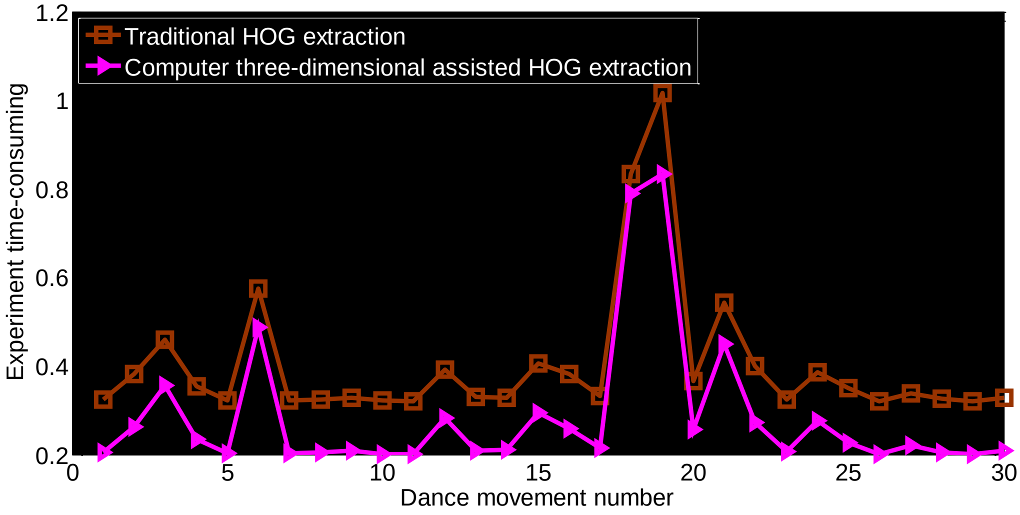

Figure 7: Comparison of experimental time-consuming on the DanceDB dataset.

5 CONCLUSION

We research on various three-dimensional computer-aided algorithms applied to dance movements, and select the moving cube method (MC algorithm) for three-dimensional computer-aided. Aiming at the lack of standard MC algorithm, an improved MC algorithm is proposed. Using binary image data after image segmentation for three-dimensional computer-assisted, more accurate segmentation results can be used to extract isosurfaces, avoiding the limitation that the standard MC method is only suitable for threshold segmentation. The problem is to realize the computer-assisted three-dimensional model without holes; the interlaced search method is adopted to quickly find the boundary cube, and the three-dimensional computer-aided efficiency is improved; the midpoint of two adjacent points is used instead of the linear interpolation calculation point as the triangle vertex. The effect is greatly reduced at the same time. We have specially produced a dataset of folk dances. During the production process, we formulated a detailed data set recording plan, and discussed with professional dance experts about the production of dance data sets. In the later specific recording process, we used the Vicon motion capture system to invite different dance students to group according to dance. At the same time, considering that the current dance movement recognition research is still in its infancy and the dance moves are too complex, our data set is recorded in a fixed scene and a single person performing dance performances. At present, a total of three dance moves have been completed in four groups.

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