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*Research Article*

# Research on Dance Motion Capture Technology for Visualization Requirements

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"Motion capture technology" refers to the use of optical sensing equipment to record the dancer's movement trajectory during dance and then convert this movement trajectory into applicable data information in animation software. In the 3D animation software, the corresponding dancer model can be constructed, and the matching costumes can also be designed. After combining it with the motion capture data, animation and dance data can be generated. In this way, virtual simulation software can create some virtual visualization scenes and present more diverse and complex demonstration effects. This article focuses on three aspects: "an overview of the connotation of motion capture technology," "design of virtual dance visualization scene based on motion capture technology," and "application of virtual dance visualization scene based on motion capture technology."

## 1. Introduction

"Motion capture technology" was initially applied in a very narrow field, mainly in the field of animation films. With the maturity of motion capture technology, its application fields are becoming more and more extensive, such as motion analysis and sports training. A complete motion capture system usually includes multiple parts such as signal acquisition equipment, data processing, data transmission, and sensors [1]. At present, motion capture systems mainly include optical motion capture systems, electromagnetic motion capture systems, and mechanical motion capture systems. What we call motion capture today usually refers to the use of sensors and software to transcribe the movements of real actors into the movements of digital models in 3D games or animations. As we all know, characters (including characters and animals) in animation and games must have actions, such as running, jumping, and fighting. The "optical motion capture system" has better stability and higher precision. The dance data is presented through an optical motion capture system, and the effect will be better [2].

Regarding the connotation of motion capture technology, it can be understood as a computer recognition technology, which is mainly used to recognize data information during motion. Through motion capture technology, various real actions of people in three-dimensional space can be collected, and the collected data information can be entered into the virtual model, thereby generating a series of motion data records [3]. Mechanical motion capture relies on mechanical devices to track and measure motion trajectories. A typical system consists of multiple joints and rigid links, and angle sensors are installed in the rotatable joints, which can measure the changes in the rotation angle of the joints. When the device moves, according to the angle change measured by the angle sensor and the length of the connecting rod, the position and movement trajectory of the endpoint of the rod in space can be obtained. In fact, the motion trajectory of any point on the device can be obtained, and the rigid link can also be replaced with a telescopic rod with a variable length, and the change in its length can be measured with a displacement sensor. An early mechanical motion capture device uses joints and links with angle sensors to form an "adjustable digital model" whose shape can simulate the human body or other animals or objects. The user can adjust the posture of the model according to the needs of the plot and then lock it. The angle sensor measures and records the rotation angles of the joints. According to these angles and the mechanical dimensions of the model,

the pose of the model can be calculated, and these pose data are transmitted to the animation software so that the character model in it can also make the same pose. This is an early motion capture device, but there is still a certain market until now. Foreign countries have given this device a very vivid name: "Monkey." An application form of mechanical motion capture is to connect the moving object to be captured with the mechanical structure, and the motion of the object drives the mechanical device, which is recorded by the sensor in real time. The advantages of this method are low cost, high accuracy, real-time measurement, and simultaneous performance of multiple characters. But its shortcomings are also very obvious, mainly because it is very inconvenient to use, and the mechanical structure greatly hinders and restricts the movements of performers. The "monkey" is more difficult to use for real-time capture of continuous actions. It requires the operator to continuously adjust the posture of the "monkey" according to the requirements of the plot, which is very troublesome. It is mainly used for static modeling capture and key frame determination. Moreover, this motion data information can be well recognized by the computer. After the relevant personnel put this motion data information into the 3D animation software, they can build a "3D human body model" in the 3D animation software. The three-dimensional mannequin is both virtual and vivid and can depict the dancer's facial features according to the dancer's physical fitness. Society is progressing, science and technology are developing, and computer hardware and software equipment is becoming more and more perfect. Many researchers choose to conduct scientific research and auxiliary teaching training through computers. Motion capture technology is the latest scientific and technological research project that has been developing and growing in recent years. Through the motion capture system, the animation production of film and television entertainment, the rehabilitation of patients in the medical field, the field of sports training, and the analysis of digital human motion posture assisted by college teaching are realized, and the guidance of rigorous scientific theory is provided [4]. This paper analyzes the motion posture of the human body, proposes a posture analysis method based on eigenvector matching, and analyzes the characteristics of the motion posture of the human body based on the real-time characteristics of the optical motion capture system,. This paper analyzes the development prospects and research significance of motion capture technology in sports dance teaching, provides an effective theoretical basis for scientific training, promotes the efficiency of students' learning, and effectively improves the scientific research level of education and teaching. The main research work of this paper is as follows: (1) A dance posture analysis method based on feature vector matching is proposed, which can accurately analyze the dance movement posture of the human body, obtain the difference in effective human movement, and provide theoretical support for the scientific training of dance. (2) Applying motion capture technology to the research of dance teaching in colleges and universities, by tracking, capturing, checking, recording, etc. of human movement, the dance movements are demonstrated in sections, which solves the traditional problem of repeated demonstrations when teachers teach, get rid of the interference of students or teachers due to individual differences, psychological, physical, and other factors, and, through the effective analysis of computer data, timely find problems and correct them, which greatly improves the efficiency of education and teaching. The advantages of this study are mainly connected with the dance teaching through the optical motion capture system, which improves the intuitiveness of the learning effect. The collection and analysis of real-time data provide timely feedback for teaching. From the technical level, teaching form, and student acceptance level, it provides scientific theoretical support in terms of innovation and other aspects, gets rid of other interference factors of the traditional teaching mode, provides a reliable basis for the improvement of the teaching mode, and helps the system to improve the personalized teaching system. The next main research work is to complete the real-time analysis of human motion posture with the assistance of the optical motion capture system.

In addition, the technology can also build a variety of clothing models. Due to the large number of ethnic minorities in our country, there are also many dances with ethnic characteristics. When building costume models, you can refer to the styles of different ethnic groups and different dances. After the construction of these models is completed, they will enter the next step of construction, that is, "three-dimensional bones" [5]. In this process, the 3D skeleton is meant to correspond to the model. Only when the correspondence is good, can we lay a good foundation for "skinning" [6]. The main function of skinning is to make the bones and the model closely connected to form a whole, making it look more harmonious and unified. At the same time, the relevant personnel must match the corresponding costumes and match the costumes, bones, and models into a set. At this time, the data information transmitted by the motion capture system can make the 3D model move and become various animations that people see. According to the needs of the market and people, these animations can be placed on the virtual platform, which is mainly used to save dance information, demonstrate dance content, and create new dance materials [7].

The advent of motion capture technology dates back to the 1970s. With the rapid development of computer software and hardware technology and the improvement of animation production requirements, its application fields cover many aspects, such as film and television production, virtual reality, games, ergonomic research, simulation training, and biomechanical research [8]. In principle, the commonly used motion capture technologies can be divided into four types: mechanical, acoustic, electromagnetic, and optical. Optical motion capture is currently the most commonly used motion capture technology. It accomplishes the task of motion capture by tracking specific light points on the target [9]. At present, common optical motion capture is mostly based on the principle of computer vision. When the camera continuously shoots at a high enough rate, the movement trajectory of the point can be obtained from the image sequence, as shown in Figure 1.

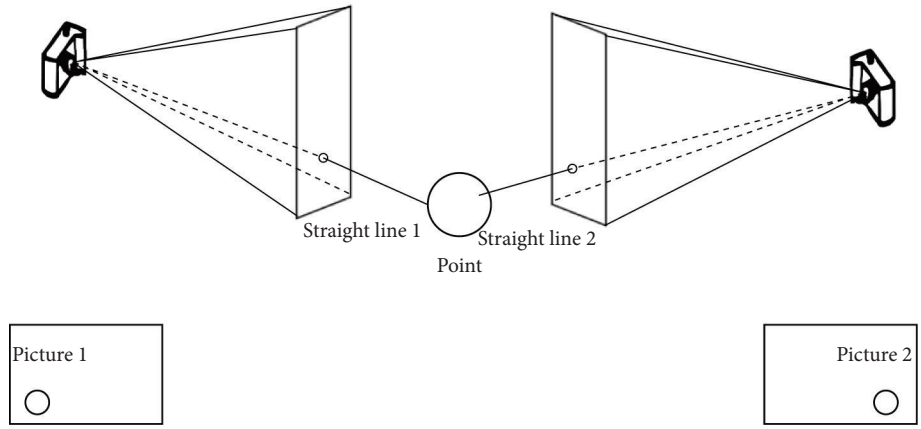


Figure 1: Optical motion capture system.

The advantage of optical motion capture is that the performer has a large range of motion, no cables, and the limitation of mechanical devices. The performer can perform freely and it is very convenient to use. Its high sampling rate can meet the needs of most high-speed motion measurements [10]. The disadvantage is that the system is expensive, and although it can capture real-time motion, the postprocessing (including Marker recognition, tracking, and calculation of spatial coordinates) takes long time. At present, it cannot achieve real-time driving of the character model and real-time viewing effects. Such systems are sensitive to lighting and reflections in the performance venue. The device calibration is also more complicated [11]. Especially when the motion is complex, the markers in different parts are easily confused, and the occlusion produces wrong results, which often requires manual intervention in the postprocessing process [12].

## 2. Related Technologies

### *2.1. Design of Dance Virtual Visualization Scene Based on Motion Capture Technology*

*2.1.1. Dance Data Collection.* "Dance data acquisition" is the first step in the dance virtual visualization scene design of motion capture technology. Data acquisition is a prerequisite and foundation in the process of dance digitization. In the process of dance digitization, data acquisition is a prerequisite and foundation. Only after the data information has been collected, the data information can be presented through the subsequent virtual display platform [13]. At present, dance data collection mainly includes three parts: first, "collecting dance materials." There are many dance materials in our country, and there are many channels for collection, such as individual performances, stage performances, and folk visits. The relevant personnel should prepare the collection equipment in advance and choose more advanced digital cameras, digital cameras, etc. Second, "digitize the material." After the dance materials are collected, they should be systematically organized. During this process, the relevant personnel should actively listen to the suggestions of professional dancers, make reasonable use of the dance materials, and then perform dance demonstrations based on the dance materials finally sorted out. Through the motion capture system, capture those classic dance moments and realize the digitalization of dance. Third, "Building 3D Models." The three-dimensional model is constructed in 3 ds Max. The reference is based on the general body proportions of most men and women, and the corresponding costume models are established in combination with dance characteristics. It should be noted that the models are mainly divided into two types: one is the "fine model," which is generally not displayed on the virtual platform and is mainly saved as a kind of data which saves 360-degree video files; the other is the "fine model." One is the "simple model," which is mainly used for virtual platform display. There are many classifications of dance, and combined with the characteristics of different dances, it is also possible to carry out "key binding," that is, to systematically evaluate the bound skeletal model and set relevant weights [14].

*2.1.2. Dance Animation.* Dance animation can be understood as the combination of "3D animation" and "motion capture data." 3 ds Max, MotionBuilder, and other software can well link 3D animation and motion capture data [15]. At this point, the work of data acquisition and dance animation is basically completed. After that, export the model file, motion data, etc. through 3 ds Max, and save it in FBX format.

*2.1.3. Display System.* At present, the "display system" mainly uses the three-dimensional game engine UNITY 3D. This display system includes the following modules:in the opening session, just like film and television dramas, basically every three-dimensional animation video will introduce some basic information, such as production unit, content introduction, system name, which has become a conventional general title module; dress-up module - In short, this module is mainly used to change clothes, according to different regions, different dance style, and switch between different clothing animation models; camera control module: - unity 3D is a very popular 3D game engine

because it has a very powerful control ability, through the dance movements presented by the 3D model. The viewer can observe from various angles, and can basically achieve a 360-degree panorama. At this time, the viewer will feel very wonderful. The presentation of the dance and the change of perspective can be controlled by a small mouse in the hand. At present, the camera control module can be programmed independently, or the default control system can be used: the dance selection module—the classification of dance can be measured from different dimensions. The dance selection module is mainly used to select the type of dance. At present, the main types of dances are dances performed on a large scale and in a standardized manner on major holidays, some minority dances circulated in the folk, some collective dances created by people spontaneously, and some dances composed and performed by dancers with special talents, used for dances on some special occasions, with certain funny elements and commemorative meanings in Children's Day, weddings, and corporate annual meetings; gender selection module - the role of this module is well understood, which is to distinguish male dancers and female dancers. In the three-dimensional game engine U-NITY 3D display system, through the coordinated operation of these five modules, the effect of virtual demonstration is finally presented [16].This system can now be used not only on computers but also on mobile phones.

*2.2. Application of Virtual Dance Visualization Scene Based on Motion Capture Technology.* By first collecting text records, taking pictures and videos, obtaining relevant text, pictures, and video-related materials of Lusheng Dance, performing dance choreography, and using motion capture equipment to record dance movements to obtain dance movement data. At the same time, 3D StudioMax is used to preliminarily establish dancer characters model. After having motion data and a dancer model, digital postproduction can be performed to realize animation display [17]. The production process is shown in Figure 2.

At this stage, the application of dance virtual visualization scene based on motion capture technology is mainly reflected in the following aspects:

*2.2.1. Teaching Field.* When teaching dance classes, art teachers can use the virtual display platform to digitally present dance, bring students more abundant teaching content, facilitate students to learn "dance movement decomposition," and facilitate teachers to carry out dance-related activities. research [18].

*2.2.2. Multimedia Display Field.* In the field of multimedia display, the application of dance virtual visualization scene based on motion capture technology can combine traditional dance teaching content with modern technology, such as three-dimensional dynamic imaging technology, human scene synthesis technology, phantom imaging technology, and laser technology. This gives viewers a new impact. From the perspective of dance research, this is an efficient research method, that is conducive to improving the accuracy and standardization of dance research.

*2.2.3. Internet Field.* The application of dance virtual visualization scene based on motion capture technology can well adapt to the Internet environment and compile and generate some dance content that can be disseminated and displayed in the Internet environment. With the increasing number of mobile phone users, the Unity 3D game engine can also compile and generate mobile apps, so that more people can enjoy this convenient service anytime, anywhere, and feel the popular educational atmosphere of dance in the new era. The dance of the public has broadened the path of inheritance and development.

## 3. Dance Motion Capture Technology Based on Visualization Requirements

To meet the needs of efficient and high-precision human gesture recognition methods, an efficient gesture analysis method based on similarity matching between feature planes is proposed. The human motion data is collected in real time through the optical motion capture system, and the skeleton and its human feature plane are effectively extracted. Furthermore, an efficient matching mechanism is established by taking the plane feature vector and its included angle as the judgment basis for attitude analysis. This method is combined with dance teaching. After experimental verification, it not only provides a stable and accurate analysis of human posture but can also effectively obtain the difference between human movements, thus providing good theoretical support for dancers to carry out scientific dance training [19].

*3.1. Acquisition of 3D Data from Motion Capture.* In this paper, an optical motion capture system is used to obtain motion data, thereby establishing a database of the human motion pose models and skeleton model. The basic process is as follows, as shown in Figure 3.

*3.1.1. Real-Time Acquisition of 3D Human Motion Data.* In the data collection, the performers first put on monochrome clothing with 21 markers on key parts, stand within the preset motion space, start the high-precision 3D motion capture software, set the specified time, and press. It is required to shoot the specified dance movements and use the camera to capture and track the movement of the 21 marker points. Match the captured and edited human motion data of 21 marker identification points with the actor model, activate the 21 identification points to complete the data matching with the actor, so as to complete the establishment of the database of human motion posture.

*3.1.2. Establish Motion Model Database.* Applying the motion capture system to analyze the motion posture of the human body is to estimate the motion posture characteristics of the human body from different perspectives. In this paper, the key points of the motion feature are used to mark

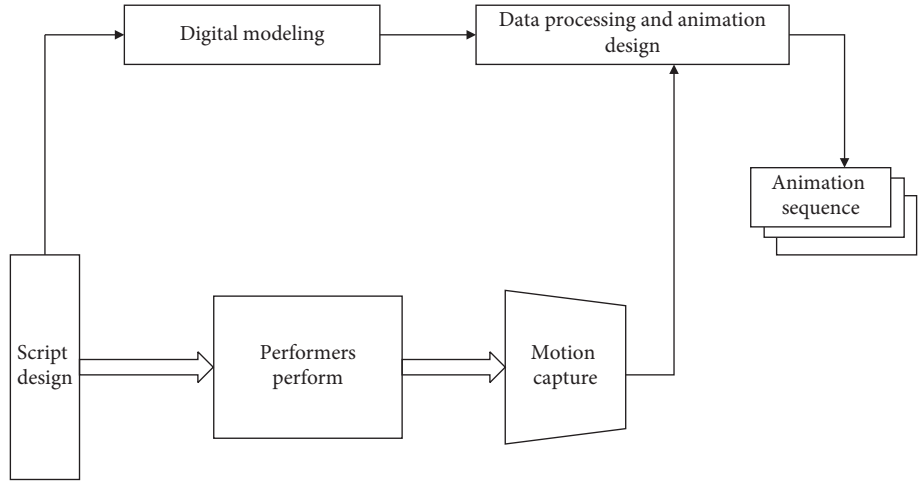


Figure 2: Production process.

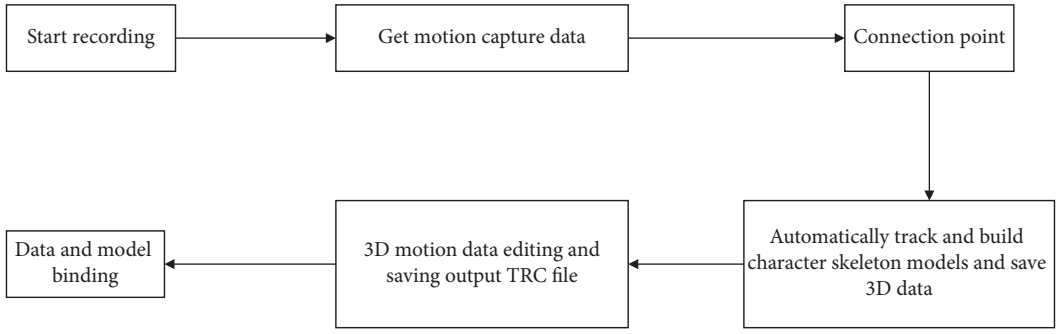


Figure 3: 3D data acquisition flow chart.

the key parts of the human body. The connection between the key points represents the rigid body. When they are "shape unchanged," the connections between key points represent rigid bodies [20]. The main research on movement posture is to build a database of human movement postures based on the head, body, hips, and limbs.

*3.1.3. Human Motion Pose Analysis Based on Feature Vector Matching.* Movement posture analysis is the process of tracking, capturing, acquiring, and analyzing human body posture characteristics so as to obtain relevant movement posture parameters. Through the effective combination of motion analysis and teaching, the teaching system can be more personalized and featured, and the performers' performances can be decomposed in detail, and each dance movement can be demonstrated step by step. The parameters obtained are conducive to quantitative analysis of the movement posture, providing good help for more scientific and intelligent dance teaching [21].

In order to better analyze the motion state of dance performers, a method for analyzing human motion posture using the principle of feature plane similarity matching is proposed. This method simplifies the traditional calculation of Euclidean distance based on multiple identification points to the calculation of a feature plane feature vector and its included angle [22]. In this paper, the identification points of 21 key parts are simplified into 7 feature planes to calculate the motion difference and correlation. Through verification, this method can quickly and effectively analyze the motion posture of the human body and can be applied to dance teaching to improve the efficiency of dance teaching. The specific process is as follows, as shown in Figure 4. The main steps of the analysis process include the following:

Step 1 Real-time acquisition of skeleton data: in the form of optical motion capture, real-time acquisition of dance action sequences, and storage of the coordinates of each identification point of the human body model in the space coordinate system.

Step 2 Posture analysis: determine 7 feature planes according to the feature points, extract the angle between the feature vector and the posture feature vector, and calculate the feature correlation coefficient of the human body posture according to the motion characteristics of the key parts of the dance movement.

Step 3: Analysis of the difference degree of characteristic posture: through the correlation coefficient of the characteristic vector and its included angle, analyze the difference and accuracy between the dance movements and standard movements of the students.

The motion of the human body is a complex process. Without considering conditions such as muscles and

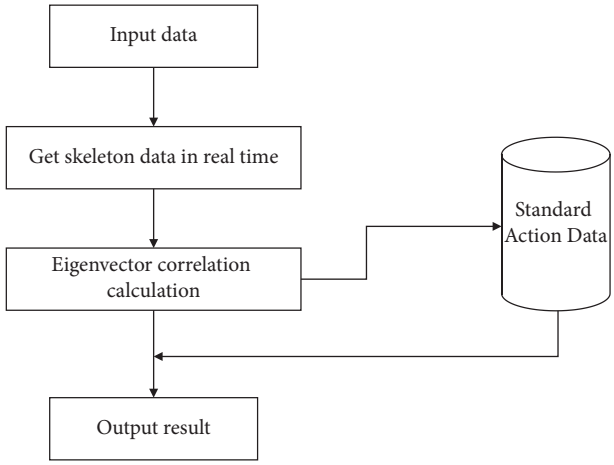


Figure 4: Method flow chart.

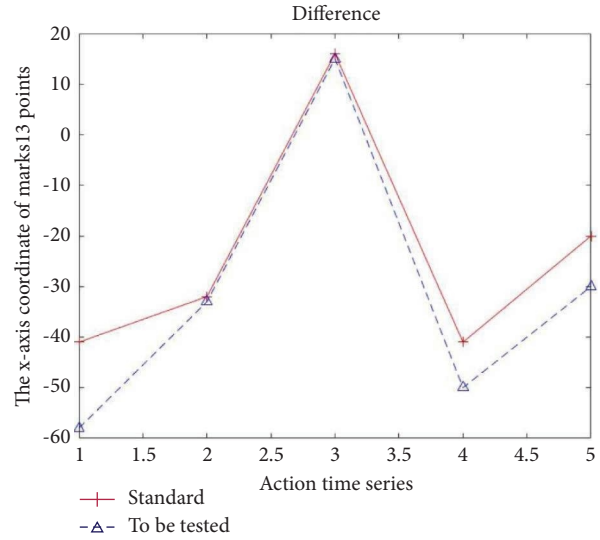


Figure 5: Comparison of motion trajectories in one direction between single identification points.

nervous systems, the motion of the human body can be abstracted into a simple chain system connected by some rigid bodies [23]. The upper limb is composed of two rigid bodies connected by the elbow joint, the upper arm, and the forearm; the lower limb is composed of the two rigid bodies of the thigh and the calf connected by the hip joint, and the thigh and the calf are connected by the knee joint. The body and hip are also represented as a rigid body by a line connecting the joint points [24].

*3.2. Traditional 3D Model Similarity Matching.* The similarity matching of human body poses is to realize the measure of the difference or similarity of the poses between different human bodies. The most commonly used method is the traditional Euclidean distance metric.

The traditional 3D model similarity matching is based on the Euclidean distance, and the calculation methods are as follows:

$$D = \text{sqrt}\left((x_1 - x_2)^2 + (y_1 - y_2)^2\right),$$
$$D = \text{sqrt}\left((x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2\right). \quad (1)$$

With two identification points, the difference between the two identification points can be obtained through the calculation formula based on the Euclidean distance. If the obtained difference is less than the threshold, the threshold is set by the coach, and the two identification points are considered to be similar. If the difference is greater than this threshold, the two identification points are considered dissimilar. The standard action is compared with the trajectory of the same identification point of the action to be tested, as shown in Figure 5.

The direct comparison method based on the traditional Euclidean distance is to compare the activity trajectories of two moving targets, and the corresponding distance difference will be obtained during the comparison of each action sequence, and the data matching degree will be calculated according to the preset threshold. However, this method not only requires too much calculation but also depends on the inherent characteristics of the object to be measured. When the body ratio of the object changes, such as height, short, fat, and thin, the distance between the marking points also changes accordingly, and it must be repeated. Therefore, due to the strict requirements for moving objects, the use of traditional methods is limited, which not only greatly reduces the computational efficiency but also lacks universality [25].

The traditional form of dance teaching is generally taught by the teacher's oral and deeds, through oral movement essentials and personal demonstration of dance movements to students, so that students can understand the essentials of movements in class. However, in traditional sports teaching, the internal reasons such as high difficulty, fast speed, difficult memory, and the instantaneousness and complexity of movements lead to increased teaching difficulty. Teachers cannot standardize each movement due to psychological, physical and other factors. It is shown meticulously that due to individual differences and different observation angles, students cannot master the essentials of movements in this class, which has an impact on the understanding of the key and difficult points of dance movements, so that teachers have to repeatedly demonstrate and explain, which affects teaching efficiency. The teacher's oral and deed teaching method has a single teaching form, and the students only focus on movement practice and lack the ability to think actively.

The combination of motion capture technology and teaching will make up for the deficiencies of traditional teaching forms and has advantages that traditional teaching does not have in the acquisition and transmission of motor skills. According to the students' own state, they can purposefully learn and demonstrate the movements, and then compare them with the standard movement postures according to the analysis results of the three-dimensional movement data and correct the standard movements in time, which is beneficial to the students' learning and performance. Teachers' teaching efficiency has been greatly improved.

The teacher's standard dance movements are made into three-dimensional teaching animations through motion capture technology. Before class, students learn the dance movements in the teaching animations by themselves, and draw gestures and movements in their minds while watching the animation. Repeated demonstrations are performed in multiangle segments, and then students perform real demonstrations. The high-precision 3D camera of the motion capture device captures the movements demonstrated by the students and compares them with the teacher's standard movements. The teacher can give students specific goals through the comparison of 3D data. The guidance helps students master the essentials of standard dance movements, and students can make self-correction according to the analysis results. Throughout the development of computer-assisted teaching, computer science, educational technology, cognitive psychology, etc have had an important impact on the development of motion capture technology-assisted dance teaching. The kinds of enlightenment that can be obtained are as follows:

(1) From the technical application point of view, motion capture technology establishes a teaching model database and generates teaching animation videos, which makes the computing technology-assisted dance teaching more concise, easy to understand, vivid, and so on, gives full play to the role of virtual reality technology, and analyzes students' mastery. It provides learning navigation and suggestions for students' dance movement learning; students realize independent learning and inquiry learning, and teachers can assist students' learning process from the side, so that students' "learning" and teachers' "teaching" are more in line with the concept of digital teaching; it is also more feasible at the technical level.

(2) From the perspective of teaching form, due to the innovation of teaching methods, teachers are guided to fully realize the teaching advantages of motion capture technology - 33 -, play the leading role of teachers, get rid of the shackles of traditional teaching methods, and create indoor training classrooms for different dance forms, such as ballet, Latin dance, folk, dance, can use motion capture technology to quickly, and effectively help students discover the completion of their own movements through detailed demonstrations and real-time effects feedback, thereby making up for irregular movements. Students learn the essence of the movements to be mastered in the form of self-learning, which is conducive to giving full play to the initiative of students in learning, fully realizing the main body of students' learning, enhancing the pertinence and timeliness of teaching effects, and improving the attractiveness and effectiveness of classroom education models. Infectious is conducive to enhancing the level of students' reform and innovation.

(3) The dance teaching form based on motion capture technology is the intersection of computer science, educational science, and teaching psychology. This technology can improve teaching quality, enhance teaching appeal, and make motion capture technology make creative progress and development in the scope of computer-aided instruction.

## 4. Conclusion

The virtual visual scene design of dance based on motion capture technology is of great significance for the diversified presentation and inheritance of dance, especially for some relatively classic and small minority dances, because fewer people learn these dances, these dance forms are facing a crisis of inheritance. The virtual visual scene design of dance based on motion capture technology can better protect these minority ethnic dances, so that more people can see the charm of this dance and are willing to inherit and develop it.

## Data Availability

The dataset can be accessed upon request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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