Analysis of Three-Dimensional Human Movements and Its Research in Sports Dance Teaching

Ruili Zheng[1,*] and Jingqi Zhang[2]
[1]*Physical Education Research Department, Xinjiang University, Urumqi, Xinjiang, China*
[2]*Office of the president of the Party Committee, Xinjiang Institute of Engineering, Urumqi, Xinjiang, China*

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Abstract: Since human beings are the most important element in the natural and social environment, various human activities are accompanied by a wealth of important information about the interaction between humans and nature, and between humans and society. The automatic learning and recognition of human action behavior is of great significance in the fields of advanced human-computer interaction, automatic monitoring of human behavior, and intelligent analysis of sports, and has a wide range of application prospects. This article mainly studies the three-dimensional human movement analysis and its application in sports dance teaching. This article summarizes three methods for obtaining 3D human action skeleton data, and uses depth map sequence as the method for obtaining action skeleton data in this article. Then, the 3D human skeleton model and action pose feature description method in this paper are proposed. This article describes the key frame extraction method of 3D human motion data, summarizes the characteristics of 3D human motion data, and analyzes the current main key frame extraction methods. This paper studies the 3D human action recognition methods and analyzes the advantages and disadvantages of various recognition methods. This article studies the current state of sports dance teaching, and based on this, proposes a teaching method that combines sports dance with three-dimensional human movement analysis. Through experiments, it is found that when analyzing the movements in the dance process, the estimation errors of the human head, pelvis, upper and lower arms and upper and lower legs in the first 300 frames are all under 70mm, which can accurately analyze the current dance movements. The standardization can help students learn dance better.

1 INTRODUCTION

With the vigorous development of our country's economy and the continuous acceleration of the pace of people's lives. Faced with the ever-increasing pressure of life, people devote more time to work and study, while the time allocated to physical exercise and dance art is getting less and less, which invisibly leads to a general decline in the physical fitness of the public (Purvis and Denise, 2016). With the rapid development of the electronic information industry, more and more electronic products are applied to all areas of life (Wei, 2017). In this article, a sports dance teaching method using a three-dimensional human movement analysis instrument is proposed to help students learn dance.

Many scholars have conducted research and analysis on three-dimensional human movement analysis and its application in sports dance teaching. For example, Ayame Yamazaki, Takuo Ikeda and Takeshi Tsutsumi applied video fundus photography technology to three-dimensional recording and analysis of eye movements, which required quantification of the main sequence (Borgogno, 2017). They used infrared images to obtain the characteristics of the torsion fundus and analyzed its main sequence (Hooshang and Eric, et al. 2016). Guo Yusun, Chen Wenjuan and others proposed a new dance self-learning framework based on Laban's motion analysis principles (Yamazaki and Ikeda, et al. 2019), so that students can automatically analyze dance movements and correct dance skills without an expert (Sun and Chen , et al. 2017). They proposed a "shape-effort" feature description model to reflect the subtleties of dance movement.

This article introduces the related technologies of 3D human motion analysis in detail, including 3D human motion skeleton data acquisition method, motion key posture frame extraction method and human motion recognition (Wang and Huang, et al.

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2016). This article introduces the current situation of sports dance teaching, and puts forward a sports dance teaching method based on three-dimensional human movement analysis technology (Jiang and Zhang , et al. 2017). This article analyzes the error of each limb joint when the three-dimensional human body movement analysis instrument analyzes sports dance movements through experiments (Migliorati and Cevidanes , et al. 2021). This article analyzes the effect of three-dimensional human movement analysis on sports dance teaching through experiments.

2 RESEARCH ON THE ANALYSIS OF 3D HUMAN MOVEMENT CHARACTERISTICS BASED ON VR TECHNOLOGY AND ITS APPLICATION IN THE DESIGN OF SPORTS DANCE TEACHING SYSTEM

2.1 3D Human Motion Analysis Related Technology

2.1.1 Three-dimensional Human Body Motion Skeleton Data Acquisition Method

In computer vision, there are three main methods to obtain 3D human action skeleton sequence: based on multi-view 2D video image sequence reconstruction, based on 3D motion capture system acquisition and based on depth map sequence mapping (Shogo and Yasuhiro, et al. 2018). Due to differences in human body shape, lack of depth information in 2D images, and partial self-occlusion, it is difficult to accurately estimate 3D human bones (Fan and Zheng, et al. 2018). At present, the 3D skeletal joint data of the human body is mainly obtained by two methods based on the 3D motion capture system and the depth map sequence. The 3D skeletal joint data obtained based on the motion capture system has higher accuracy and fewer noise points, but the motion capture equipment is expensive, cumbersome to use and generally not applicable (Peng C and Pan B Z, et al. 2020). Based on the depth information collection and mapping methods of the depth sensor, the prediction of 3D bone joints usually has errors, and the depth map will also contain noise, but the depth sensor is small in size and has universal applicability.

2.1.2 Action Key Pose Frame Extraction Method

The key posture framework of the three-dimensional human body action refers to the posture that can best reflect the action changes in the action and represented by the 3D bone joint coordinate data. The current 3D motion data key frame extraction methods are mainly divided into two types: uniform sampling extraction and adaptive sampling extraction. Uniform sampling extraction refers to re-sampling the motion sequence at equal time intervals. Due to the problems of undersampling and oversampling (leading to missing and redundant key frames), this method has not been widely used. The method of adaptive sampling to extract key frames usually uses the original motion data to be converted into motion feature description, and automatically extracts the posture of the key frame by analyzing the motion posture feature of the action posture sequence, which solves the uniformity problem well. At present, the adaptive sampling and extraction of key frames are mainly divided into three categories: frame subtraction, curve simplification and clustering.

2.1.3 Human Action Recognition

Human action recognition research belongs to the category of pattern recognition. After describing the mathematical model of action posture features, it mainly includes two basic tasks: standard action classifier design and action classification recognition. According to the characteristics of the algorithm, action recognition algorithms are mainly divided into three categories: methods based on template matching, methods based on state space, and methods based on syntax analysis. The template-based method is easy to implement, does not require a large number of training action samples, has a small amount of calculation, and has a higher recognition rate when the quality and parameters of the reference template are both optimized. However, this method is sensitive to the length of the action gesture sequence and noise points, and its robustness is not good enough. It is usually suitable for the classification and recognition of simple actions. The method based on state space can effectively overcome the problem that template matching is sensitive to noise. The algorithm has high robustness and can recognize simple and continuous actions. It is the current mainstream action recognition method and is widely used. However, this method also has disadvantages. In order to obtain an ideal classifier model, a large number of action samples are required for training. For a classifier

model with more parameters, the amount of calculation is relatively large. The method based on grammatical analysis is helpful to understand the complex action structure and effectively use the prior knowledge, but the current research is still in its infancy, usually combined with the first two methods.

2.2 B.VR Technology

Virtual reality technology is developed by integrating multiple technologies, including real-time 3D computer graphics technology, wide-angle stereo display technology and head tracking technology. In the VR system, the image that the user sees through the VR device depends on the position and direction of the eyes, but the human visual system and the motion system are separated, which is determined by the structure of the human brain. Using head tracking technology can link the vision system with the motion system, so that the virtual objects in the VR system look more realistic.

2.3 Sports Dance Teaching

In the past, when people wanted to learn sports dance, they usually had two choices: go to a sports dance club to learn from a teacher or learn by themselves by watching animations and videos.

2.3.1 Sports Dance Club

At present, the most commonly used method for dance teaching is the demonstration-practice method. Demonstration-exercise is a simple and reasonable teaching method that can help people learn movement and mental skills. In this method, the teacher must first demonstrate the dance for the students, and then the students imitate the teacher's movements under the teacher's on-site supervision. Afterwards, the teacher will give feedback to inform the students of their performance, thereby helping the students to further improve their dance moves. Traditionally, dance demonstrations and information feedback must be completed by a teacher. This learning model has proven to be effective, but the dependence on the teacher makes this learning model lack of convenience and flexibility.

2.3.2 Sports Dance Teaching System

With the development of technology, students can now take sports dance courses without the teacher present. Some sports dance teaching systems have been developed and put into use one after another. However, these systems can only provide simple demonstration functions, and they cannot provide any feedback information to help students improve their sports dance moves.

2.3.3 Sports Dance Class Using Three-Dimensional Human Movement Analysis

According to the current situation of sports dance teaching, the idea of combining three-dimensional human movement analysis technology with sports dance teaching system and applying it in the sports dance classroom was put forward, and a comparative experiment was done. Three-dimensional human movement analysis can more accurately analyze the current standardization of dance movements, which can help students learn dance better. The application of three-dimensional human movement analysis in sports dance classrooms helps to increase students' interest in sports dance, helps improve students' learning efficiency, and enables students' subjectivity to be brought into full play, thereby improving teaching efficiency and quality.

3 ANALYSIS OF 3D HUMAN MOVEMENT CHARACTERISTICS BASED ON VR TECHNOLOGY AND ITS APPLICATION EXPERIMENT IN THE DESIGN OF SPORTS DANCE TEACHING SYSTEM

3.1 Three-Dimensional Human Movement Analysis-Error Analysis

3.1.1 Test subject

This article collects 10 dance talents as volunteers to conduct experiments. The three-dimensional human motion analysis instrument records the physical state of the 10 volunteers when they dance the same dance, analyzes the difference between the data recorded by the three-dimensional human motion analysis instrument and the actual data, and understands the accuracy of the three-dimensional human motion analysis instrument in analyzing dance movements.

3.2 Evaluation Experiment of Dance Class Using Three-Dimensional Human Movement Analysis

3.2.1 Experimental Setup

A total of 46 students, including 29 girls and 17 boys, participated in the evaluation experiment. None of these students have any experience in dance learning. Let them learn folk dance and modern dance successively. These students were divided into an experimental group and a control group with 23 people in each group. The experimental group entered a dance class using three-dimensional human movement analysis to learn dance, while the control group entered a traditional dance class to learn. In order to ensure the quality of the experiment, three judges who have received dance training were invited to evaluate the dance movements of the students. Only when at least two people approve a student's dance move, is it considered that the student has mastered the dance move. Finally, the students who mastered the dance were invited to participate in a questionnaire survey. Among them, in the study of ethnic dance, there are 22 people in the experimental group and 19 people in the control group; in the study of modern dance, there are 23 people in the experimental group and 22 people in the control group.

3.2.2 Data Sources

This article uses questionnaires to obtain student data, and analyzes and processes these data to verify the effect of three-dimensional human movement analysis on sports dance teaching.

3.2.3 Ways of Identifying

3.2.3.1 Cross-Validation

When learning folk dance and modern dance successively, a cross-validation method will be used, that is, the experimental group learning folk dance will become the control group when learning modern dance; and the control group learning folk dance will become the experiment when learning modern dance group. In this way, all 46 students have the opportunity to learn dance in two different ways.

3.2.3.2 T-test

When verifying the learning efficiency, because the learning time is a continuous variable, this article uses the paired sample test method in the t-test to verify the efficiency of the three-dimensional human movement analysis for students' dance learning. The paired sample test statistics are:(1),(2),and (3).

$$t = \frac{\bar{d} - \mu_0}{s_d/\sqrt{n}} \tag{1}$$

$$\bar{d} = \frac{\sum_{i=1}^{n} d_i}{n} \tag{2}$$

$$s_d = \sqrt{\frac{\sum_{i=1}^{n}(d_i - \bar{d})^2}{n-1}} \tag{3}$$

Among them, $\bar{d}$ is the average of the paired sample difference, s_d is the standard deviation of the paired sample difference, and n is the number of paired samples. This statistic t obeys the t distribution with n−1 degrees of freedom under the condition that μ=μ0 is true.

3.2.3.3 Chi-Square Test

In the questionnaire survey, because the study is a non-continuous variable, this paper uses the chi-square test method to test the help of three-dimensional human movement analysis to students' dance learning and the cognitive burden it provides and the degree of student satisfaction.

4 THREE-DIMENSIONAL HUMAN MOVEMENT ANALYSIS AND ITS EXPERIMENTAL RESEARCH ANALYSIS IN SPORTS DANCE TEACHING

4.1 Three-Dimensional Human Movement Analysis-Error Analysis

The average value of all limb joint coordinate errors is used as the error of each frame. Table 1 shows the estimation errors of the human head, pelvis, upper and lower arms, and upper and lower legs in the first 300 frames.

It can be seen from Figure 1 that when the 3D human movement analysis analyzes the movements in the dance process, the estimation errors of the human head, pelvis, upper and lower arms, and upper and lower legs in the first 300 frames are all below 70mm. All the above results show that the 3D human motion analysis performs well in human body posture tracking, can more accurately analyze the current

standardization of dance movements, and can help students learn dance better.

Table 1: Estimation Error of Part of Human Body Joints During Dance

	Head	Pelvis	Lower Arm	Upper Arm	Calves	Thigh
50	22.5	16.4	54.7	37.4	31.4	25.8
100	25.7	20.1	26.8	26.4	27.3	26.7
150	22.6	22.4	62.1	32.7	43.6	27.1
200	36.7	31.6	54.3	34.1	32.2	31.2
250	34.5	32.4	52.1	33.4	34.6	32.3
300	39.8	32.7	52.9	55.2	31.7	32.8

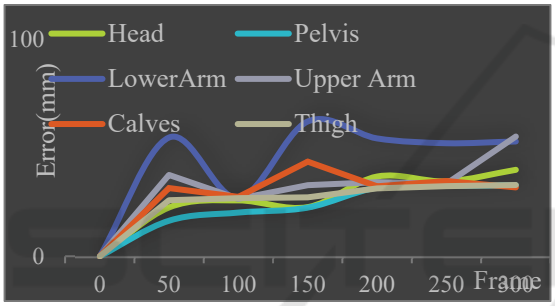

Figure 1: Estimation Error of Part of Human Body Joints During Dance

4.2 An Evaluation Experiment in A Dance Classroom Using Three-Dimensional Human Movement Analysis

Table 2 shows the results of T test and Chi-square test on the efficiency of the system, the cognitive burden of the students, the usefulness of the system, and the degree of satisfaction of the students when the experimental group and the control group are learning two types of dance.

Table 2: Test Result

	High Efficiency	Cognitive Burden	Usefulness	Satisfaction Level
National Dance	0.0007	0.0008	0.0004	0.0007
Modern Dance	0.0003	0.0006	0.0008	0.0003

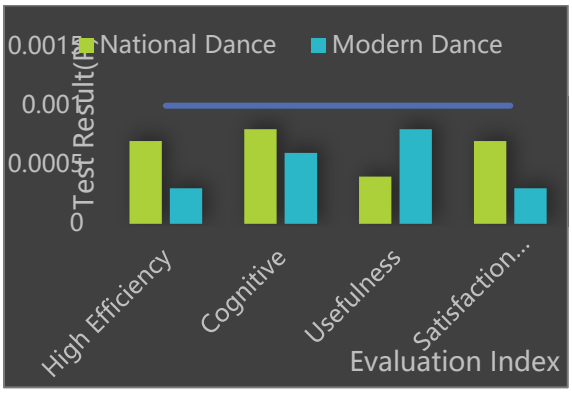

Figure 2: Test Result

From Figure 2, it can be seen that the two groups of middle school students have significant differences in the efficiency of the system, the cognitive burden of the students, the usefulness of the system, and the average evaluation of satisfaction. The P values of the test results are all below 0.001. It can be concluded that dance teaching classrooms using 3D human movement analysis are more efficient, more helpful, and more satisfying than traditional teaching classrooms. The 3D human movement analysis learning environment can provide a more suitable cognitive burden.

5 CONCLUSIONS

Nowadays, as the pace of life accelerates, people have fewer and fewer opportunities to exercise. The popularization of sports and dance art has become very difficult, and there are many reasons why people suffer because of the lack of correct guidance methods to help them exercise effectively. This article is dedicated to the development of a sports dance teaching system based on 3D human movement analysis. Our goal is to record the coach's movements and provide a three-dimensional display effect to help later students learn the movements better. At the same time, the system should have the ability to analyze the quality of sports learning, can point out and correct the errors of students' local joint points in the process of sports learning, and can also perform an overall assessment of the overall sports learning quality of students.

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