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Personal Active Choreographer

Improving the performance of the Tujia hand-waving dance.

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The Tujia hand-waving dance is an important intangible cultural heritage that is in danger of being lost, and its protection is urgent. In this article, the dance movement learning method, game-based learning concept, and evaluation are integrated in the Personal Active Choreographer (PAC) system for hand-waving dance learning. In this research, the Microsoft Kinect 2.0 was used as a game-based device to recognize and capture the movement of the user. This study was aimed at using the PAC system to improve the learning performance of the hand-waving dance, which is intended to popularize and protect it. Based on a quasi-experiment involving 60 students (average age 21.03 years), the results showed that the participants who used the PAC approach demonstrated significantly better performance and higher learning satisfaction than those who used the traditional video-instructed approach.

Our study digitizes and evaluates the Tujia hand-waving dance in three-dimensional (3-D) data and assesses the proposed method based on the experiment data. It focuses on evaluating students' dance

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performance automatically based on their movements by motion-capture technologies. It also proposes a novel approach for dance movement data analysis and evaluating learners' performance qualitatively and quantitatively using the dance movements database.

THE SIGNIFICANCE OF THE HAND-WAVING DANCE

The hand-waving dance is an important spiritual wealth created by the Tujia people. For thousands of years, it has been regarded as the epitome of social development and classic art in the long history of Tujia. The hand-waving dance is a carrier of Tujia folk culture, and it has important value for its irreplaceable role in Tujia cultural development. Unfortunately, the Tujia hand-waving dance is in danger of dying out and should be protected.

A great deal of work has been done to protect the dance. This work can be divided into the following six aspects: 1) establishing the protection mechanism, 2) developing an overall plan on a national level, 3) strengthening protection by placing an emphasis on fostering traditional cultural inheritors [1], 4) increasing coverage of the Tujia hand-waving dance by the media, 5) combining hand-waving dance culture with people's lives, and 6) creating a distinctive culture brand for the dance. However, these ways are too vague to guarantee a practical effect. In these protection methods, the Tujia hand-waving dance is usually recorded via two-dimensional methods, including text, pictures, audio, and video. Although these traditional approaches are convenient, with their use, dance movement cannot be recorded in detail for further analysis. In addition, these methods generally ignore the role of the people who act as the most effective carriers of traditional culture transmission. To develop the hand-waving dance, we need to popularize the dance with more people to help them know more about the dance and use it as a form of entertainment [2].

Against this backdrop, we take advantage of the Kinect, which is a low-cost depth-sensing camera technology that enables users to communicate with a computer in a natural way, such as with actions, gestures, language, with completely hands-free control [3]. This motion sensor technology has received widespread attention and has been widely used in dance composition and training as well as dance evaluation [4]. Kar et al. provided a new perspective to dance composition with a computer using Kinect to find out visually appealing dance sequences [5]. Similarly, Kyan et al. used a Kinect camera system to capture human movement data for ballet dance training [6], and Alexiadis et al. evaluated a dancer's performance using skeleton tracking based on Kinect [7]. These applications demonstrate that the Kinect holds the potential for dance movement recording and evaluation. Although a great deal of attention is currently focused on the Kinect and its application in dance, much less attention is paid to applying this technology to the digital protection of traditional dance. It is necessary and feasible to combine traditional culture protection with modern science and technology. This method can provide a novel way to protect and inherit traditional motor skills culture.

Based on this goal, we developed the game-based learning platform PAC with the help of the Kinect. It can be used to recognize and record Tujia hand-waving dance movement in a 3-D digital format with features of the dance. PAC provides a novel and scientific method to protect the hand-waving dance digitally. Given the significance of future research on minority dance culture protection, PAC effectively provides a novel method for more general human motion analysis.

RELATED RESEARCH

In this section, we review related studies of dance learning and game-based learning in detail.

DANCE MOVEMENT LEARNING

Watching and following movements of the choreographer are regarded as fundamental and sound principles of dance learning [8]. They are the most common methods in motor skills training and can be called the *demonstration-performance method*. The concept diagram for learning dance movement is shown in Figure 1. It tells us that demonstration and feedback are the main functions of a choreographer. The demonstration

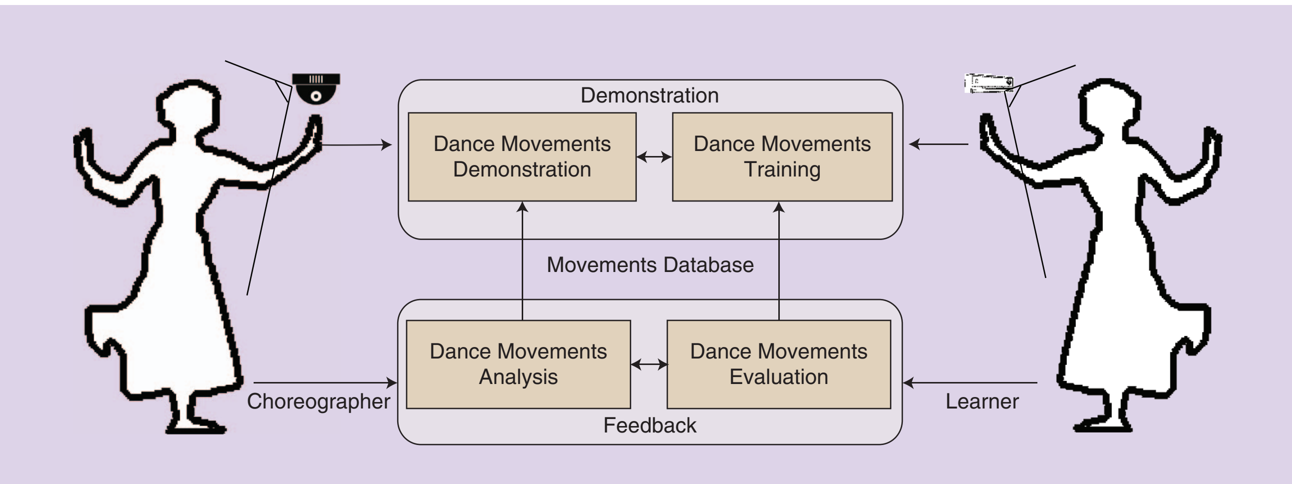

FIGURE 1. The concept diagram for learning the dance movements.

should be given by a dance coach and will be imitated by learners in the demonstration-performance method.

Meanwhile, the instant feedback from the choreographer is key to effectively learning to dance. This learning relies mainly on the choreographer watching and analyzing students' movements and fixing their nonstandard movements to improve their performance. The choreographer is expected to give a demonstration and feedback. This method is common and easy to learn, but students are not allowed to control the process of learning. Generally, the number of trainees is much larger than that of trainers, which makes it hard for the choreographer to pay close attention to each student. It is significant to be able to provide a personal choreographer for each learner so that the students can control the pace according to their individual learning process. While this dance movement learning method has gained a lot of attention, few studies have combined it with technology. To fill the gap, we mainly focused on designing and developing the PAC for the hand-waving dance to demonstrate and give feedback to a student's dance performance.

GAME-BASED LEARNING

Game-based learning has attracted the attention of many researchers because it can inspire a person's interest through interactive entertainment. Some research has focused on the reasons why game-based learning has resulted in widespread public interest and how it improves students' learning efficiency on a theoretical level [9]. Beilock and Goldin-Meadow demonstrate how body movement can influence a learner's cognition and that the motor system is connected to the mind system [10]. Game-based learning on motor skills training accounts for the highest percentage among related studies [11]. On a practical level, many studies have proved the effectiveness of game-based practice and the design and application principles of games used in instruction [12]. Game-based learning promotes learning not only for its motivation of interest but also for its support of powerful strategies for that learning, such as the authentic environment, situated learning, and optimized challenge and scaffold [13]. Given the importance of amusement in learning, PAC is designed according to the method of game-based learning and aimed at arousing a person's interest in dance.

Game-based learning promotes learning not only for its motivation of interest but also for its support of powerful strategies for that learning.

TECHNOLOGY-ENHANCED MOVEMENT RECOGNITION AND EVALUATION

Movement recognition is the first step of quantitative dance study during which a computer tests movement data and symbolizes its information. Recognizing movement is a complex process that involves moving-target detection, feature extraction, and motion pattern recognition. There are two kinds of motion-capture systems in choreography, an optical motion-capture system, in which passive or active markers are placed at the body joints, and a motion sensor device, in which movements can be captured by depth and red-green-blue information. Optical motion-capture systems are complex and expensive but accurate [14]. In the optical motion-capture system, the choreographer's key point of his or her body is marked by optical transmitters, and the cameras of the system are used to record movement data. Kinect is low cost and convenient but accompanied with noise. Because choreographers' movements will be imitated by students, the motion-capture system should be reliable and exact. For students, it is too complex to wear the markers for learning each time. Considering the feasibility and usability, an optical motion-capture system is used to record the professional choreographer's dance movement data, which will be stored in the database. The Kinect is used to capture movements of users. Standard movement matching is the main method for evaluation in PAC. Skeletal tracking technology is the core of it and can recognize 20 key points of the body accurately and track them in real time. The working principle of Kinect is illustrated in our previous research [15] and is shown in Figure 2.

In the second step, a feature extraction technique is used to simplify models to make them easier for interpretation and

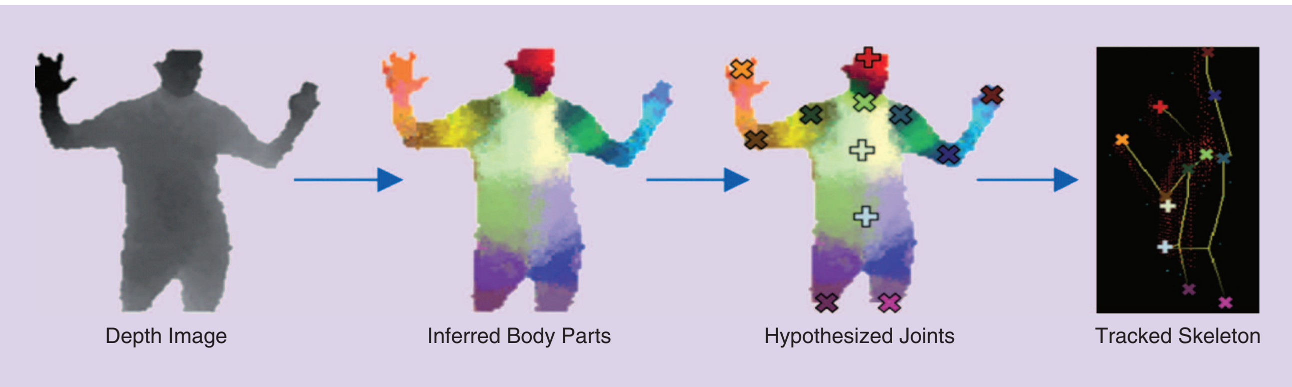

FIGURE 2. The concept diagram for Kinect motion capture.

PAC is designed according to the method of game-based learning and aimed at arousing a person's interest in dance.

enhance generalization by reducing overfitting. Based on this, we quantify movements of the choreographer and student by key skeleton-point information, including position, direction, rotation, and velocity of the body. As the last step, the motion pattern recognition can be constructed by classification of features selected from movements. Motion recognition and evaluation are often complementary to each other. The method of movement recognition usually can be used for movements evaluation, and the feedback of dance movement is key to learning.

GAME-BASED DANCE LEARNING SYSTEM PAC

The schematic description of the overall system is shown in Figure 3.

GAME-BASED DANCE LEARNING SYSTEM

The PAC needs to perform the same functions as a human choreographer, including demonstration and feedback. The standard movements demonstration is based on a standard movements database that is installed with the professional dancer's movements captured by the optical motion-capture system. The movement data will be bound to the virtual instructor model in the PAC system. The instructor driven by the standard movement data can be shown on the screen for educational purposes, and the feedback is made in real time according to the comparison of the user's movement data with the choreographer's standard movements database.

It is necessary to collect movement data of the choreographer's joints ahead of time, and it can be used as a reference to users. For learning, users can practice in front of the camera following the 3-D animation of the choreographer driven by the standard movement data of the database. The movement data of the user's joints will be captured by Kinect in real time, and the skeleton vector signals will be encoded for evaluation. We must also align the movements of the user and choreographer before comparison. Because the cameras used for movement capturing might not be synchronized, and the devices used for motion capture may be different, the coordinate system, key points of the skeleton, and entering point of the movement must be aligned before evaluation. At the same time, weightings made according to the features of the dance can promote the reliability of evaluation results. Ranking the scores of each body part and visualizing the evaluation results can help users adjust their movements and master the dance more effectively.

KEY TECHNIQUES

MOTION CAPTURE AND BINDING

Kinect is used to capture information on the 20 skeleton points of the user in front of the camera, including *x*, *y*, and *z* coordinate data for each point and the velocity, accelerated velocity, and direction of each skeleton vector. For the role of choreographer, standard waving dance movements were recorded and encoded by an optical motion-capture system according to the movement of a professional dancer ahead of time to construct a standard movements database. The format of movement is in Extensible Markup Language, and these movements can be given to the model of the instructor to provide reference to students in the PAC. Students can learn hand-waving dance movement directly in front of the Kinect camera. The movements of the user can be recorded with Kinect, and these encoded movements will be given to the virtual character model.

The 3-D motion data of the hand-waving dance after motion capture and skeleton binding of the character are used in the movement data binding process, which is completed in

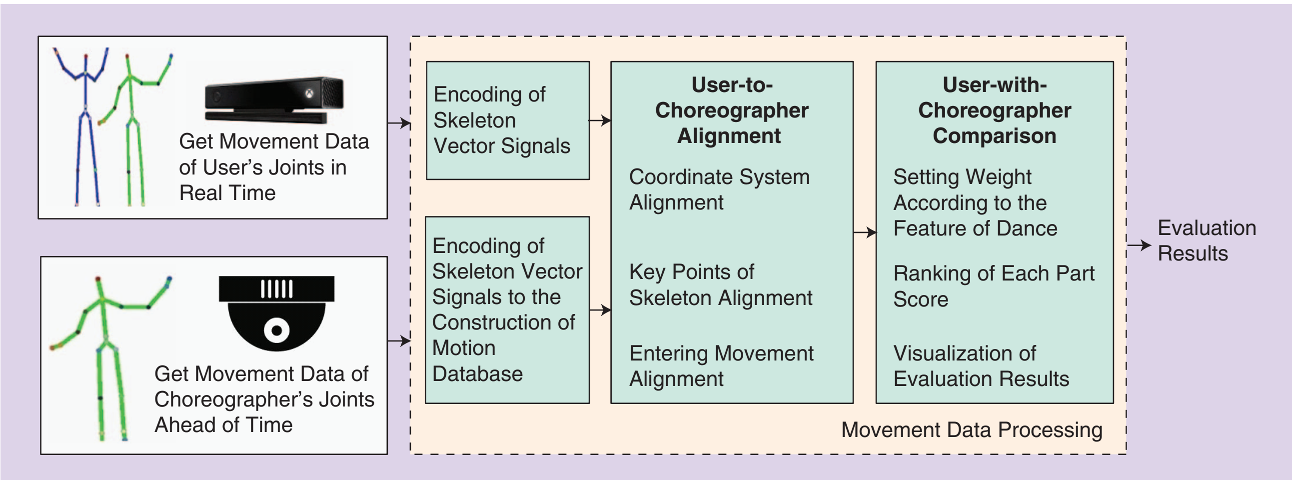

FIGURE 3. The schematic description of the overall system.

Unity 3D. There are three specific steps of this movement data binding: 1) the dance movement capture, 2) the encoding of captured data, and 3) the binding of movement data to the virtual model. The motion-capture step can make the captured movements bound in the character more accurate and natural. Each tracking skeleton point of the captured motion is mapped to the key point of the virtual character model accordingly to make the model's skeleton driven by the captured motion data. After movement binding and debugging, we import the established role model to the software and bind the motion data to the virtual actor to drive the dance character animation. The result of action binding is shown in Figure 4.

USER-TO-CHOREOGRAPHER ALIGNMENT AND COMPARISON

It has been mentioned that the device for motion capture may be different between the choreographers and users. The coordinate system of the skeletons needs to be aligned. The method of coordinate system alignment is the use of the T pose. The system can recognize the T poses of the choreographer and user and align them, because the T pose can determine the x and y axis. If the T-pose skeletons can be aligned, the coordinates of the choreographer and user will be aligned too. After alignment of the coordinate system, the movement will be aligned with dynamic time warping to avoid error caused by a time lag.

Cosine eigenvalue and weighted Euclidean distance are the two main methods for user-with-choreographer dance movement comparison. Kinect can be used to capture the motion data of users to control the virtual character in the scene. The animator element of the instructor has been combined with the standard movement data of the professional hand-waving dancer. Considering that the user's movements evaluation is carried out through the comparison of the skeletons of the user and the instructor, it is necessary to get the skeleton information for them. We can get the skeleton vectors information of the virtual user and instructor model and calculate the differences of the bone eigenvector matrix. By means of the human key points recording function of Kinect, we built 19 bone vectors with the 20 key points of the human skeleton by analyzing the bone rotation movement characteristics and structure of the human body skeleton. The structure of the 19 bone vectors of the human skeleton is shown in Figure 5. Because the key skeleton vectors of the user and instructor can be different, even if the user is performing the same dance moves as the instructor, their height and weight may be different. The dance movement represented by the eigenvalues of direction cosine of the 19 skeleton vectors can be used to remove the complexity of height and weight, i.e., the direction of each bone vector is taken to evaluate the dance movement. We then take the skeleton vector head–shoulder center (numbered 1 as shown in Figure 5) as an example to analyze the evaluation algorithm. Assuming that the 3-D coordinates of the key points of head–shoulder center are (x_1, y_1, z_1) and (x_2, y_2, z_2), the skeleton vector can be represented by $(x_2 - x_1, y_2 - y_1, z_2 - z_1)$, the three direction angles of the skeleton vector are α, β, and γ in the Unity world coordinates system, and the calculation formulas of the cosine values are shown in Figure 6.

Recognizing movement is a complex process that involves moving target detection, feature extraction, and motion pattern recognition.

After extracting the cosine eigenvalues of the three direction angles ($\cos\alpha$, $\cos\beta$, $\cos\gamma$) of the 19 skeleton vectors in the virtual human model, we recorded them in a 19×3 matrix as the eigenmatrix of the character model. Thereafter, the difference of the bone eigenvector matrix of the instructor and user model is calculated, which can be a reference to the evaluation of the user's dance movements.

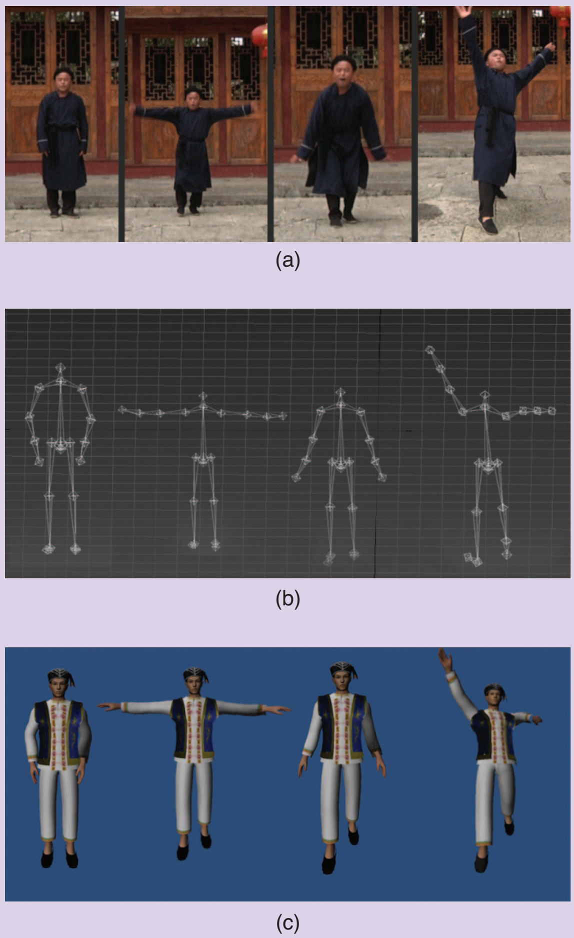

FIGURE 4. The dance movement binding. (a) Photos of the key movements by professional hand-waving dancer Chengjin Peng, (b) the skeleton of the virtual instructor, and (c) the result of movements binding.

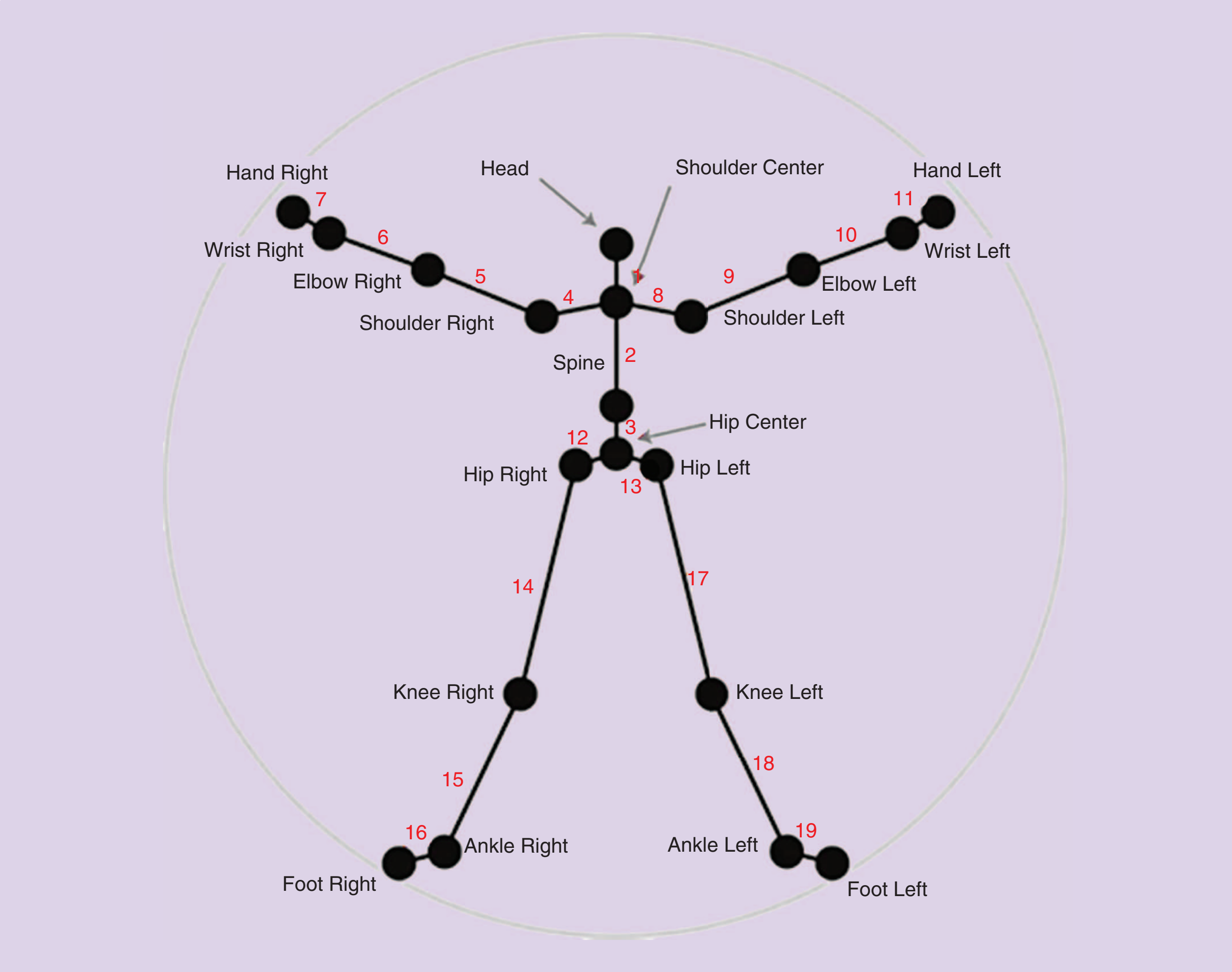

FIGURE 5. The structure of the 19 bone vectors of the human skeleton.

Various types of dance have different requests of each body part. The number of hand movements is large in the Tujia hand-waving dance, i.e., it has high requirements for hand movement. The arm bones are a significant influence on the final evaluation, so their weight should be higher than other parts of the body. To improve the reliability of evaluation, we analyzed 20 Tujia hand-waving dance videos and counted the use frequency for each part in dance movement. The statistical outcome can be used to determine the weight of each body part. The relationship between bones and their weights is shown in Table 1.

$$\cos\alpha = \frac{x_2 - x_1}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}}$$

$$\cos\beta = \frac{y_2 - y_1}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}}$$

$$\cos\gamma = \frac{z_2 - z_1}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}}$$

$$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2} \neq 0$$

FIGURE 6. The calculation formulas of the cosine values.

Weights and Euclidean distance of the bone vectors are used for dance evaluation. Let d (u, c) denote the weighted Euclidean distance between the two different skeletons of the user and choreographer, which is defined as the difference of their skeletons in the Unity coordinates system. The $d_{\max}$ is the biggest difference between the two skeletons, which can be a reference of zero, while the $d_{\min}$ represents the minimum difference between them, which is a reference of full score. The calculating formula is defined as

$$\text{score} = \frac{d(\mathrm{u},\ \mathrm{c}) - d_{\max}}{d_{\min} - d_{\max}} \times 20, \tag{1}$$

$$d(\mathrm{u},\mathrm{c}) = \frac{\sum_{p=1}^{19} d_p(\mathrm{u},\mathrm{c}) * w_p}{19}. \tag{2}$$

The formula can be used to distinguish the level of dance and limit the score on a scale of 0–20 (a full mark is 20). The

Table 1. The relationship between bones and their weights.

Number	Bone	Weight	Number	Bone	Weight
1	Head–shoulder center	0.01	11	Wrist left–hand left	0.01
2	Shoulder center–spine	0.003	12	Hip center–hip right	0.003
3	Spine–hip center	0.006	13	Hip right–knee right	0.04
4	Shoulder center–shoulder right	0.06	14	Knee right–ankle right	0.1
5	Shoulder right–elbow right	0.085	15	Ankle right–foot right	0.01
6	Elbow right–wrist right	0.15	16	Hip center–hip left	0.003
7	Wrist right–hand right	0.01	17	Hip left–knee left	0.04
8	Shoulder center–shoulder left	0.006	18	Knee left–ankle left	0.1
9	Shoulder left–elbow left	0.09	19	Ankle left–foot left	0.01
10	Elbow left–wrist left	0.17			

difference between the user and choreographer model can be calculated by combining the weights and difference of bone eigenvectors. The implementation of the evaluation algorithm is shown in Figure 7.

DESIGN OF THE PAC SYSTEM

PRACTICE MODE

The hand-waving dance is not easy for a beginner to grasp. However, it will be easier for a user to master a new dance when he or she is taught breakdowns of the dance by a coach. Practice mode is the first scene of the PAC, and users can dance by following the virtual choreographer just like imitating a real choreographer who is beside them. This mode can help new students learn more about the basic moves of the hand-waving dance because such movements are determined by the professional choreographer. In addition, each basic movement contains several frames of the static move, and the movements database contains almost all of the basic movements of the hand-waving dance for evaluation of the user's movement. Moreover, students can eventually imitate the moves of the virtual choreographer in practice mode. The player can advance to the next movement only if his or her score of the movement reaches 14, i.e., the player cannot move on until the present movement is qualified.

FEEDBACK MODE

Feedback is a key function of the choreographer. An instant feedback from the choreographer can facilitate the learning effect, which has been confirmed by many researchers. Students can master the basic movements of the hand-waving dance after practice mode, but the continuity of the whole dance still needs improvement. Hence, feedback mode is designed and developed. Users can learn the whole continuity of the hand-waving dance by following the virtual choreographer in feedback mode. Each movement of the player can be recognized and scored according to the comparison to the corresponding standard movements in the database. More importantly, the substandard four important parts can be demonstrated to help the user adjust immediately. Therefore, students receive the essentials of each movement and the whole continuity of the dance after feedback mode.

DOUBLE MODE

Constructivist learning theory and game-based learning show that companionship and joy are two key factors that influence learning efficiency. The double mode is a fusion of a learning partner, competitiveness, and enjoyment. Kinect can be used to track two dancers at the same time, so two users can learn the hand-waving dance together following the same virtual choreographer.

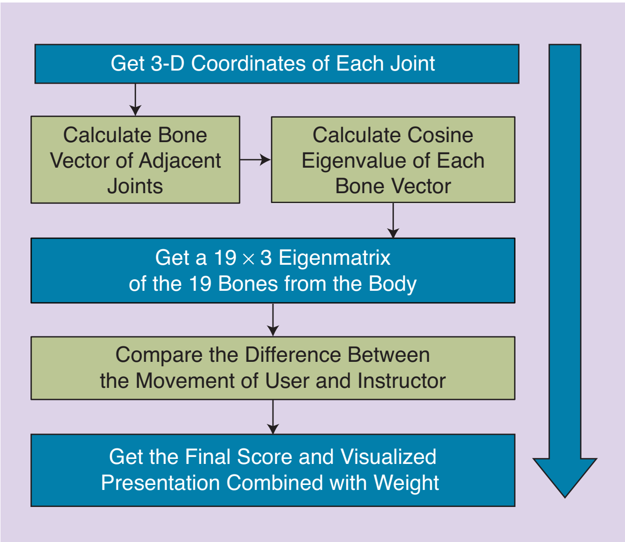

FIGURE 7. The implementation of the evaluation algorithm.

Each movement of the player can be recognized and scored according to the comparison to the corresponding standard movements in the database.

They are companions and can learn from each other. The evaluation results are the final assessment of their overall dance movement, and there will be a demonstration of comparative results to enhance their enjoyment at the end of the dance. Above all, two users can learn together and enhance learning enjoyment through competition and cooperation.

PLAYBACK MODE

People will gain new insights through looking back at their learning process. Playback mode makes it possible for reflective learning of the dance, which is not easy in traditional dance education. After learning a passage of dance, users may need to check the learning process and find out what problems exist. The function of record and replay can be used to promote the user's reflective learning. When students are aware of the deficiencies in their own learning, they can improve it correspondingly.

EVALUATION

METHOD

This research developed the PAC, a hand-waving dance game based on Kinect, to promote the learning and popularizing of the hand-waving dance. The effectiveness and usability of the PAC are key to the dance learning effect. The evaluation of the PAC sought to answer the following two questions:

1) Did students who learned using the PAC acquire better dance performances than those who learned using video?
2) Did students who learned using the PAC have higher learning satisfaction than those who learned using video?

To answer these two questions, we designed a study with an experimental group and a control group. Participants of the two groups learned the hand-waving dance in different ways. In the control group, participants practiced the Tujia dance Zhanchi (following the video) with a professional Tujia folk dancer. Participants in the experimental group practiced the same dance using the PAC and received feedback on their dance movements after practice. This experiment was used to test the effectiveness and usability of the PAC against practicing under the instruction of a traditional dance video.

PARTICIPANTS

The 60 participants in this experiment were undergraduates at Central China Normal University (CCNU), chosen randomly, with ages ranging from 18 to 24 (M = 21.03). None of the students had never learned dance before but had normal coordination. There were 24 females and six males in each group. The two Tujia folk dance teachers were from the dancing school at CCNU, both with rich experience in dance evaluation.

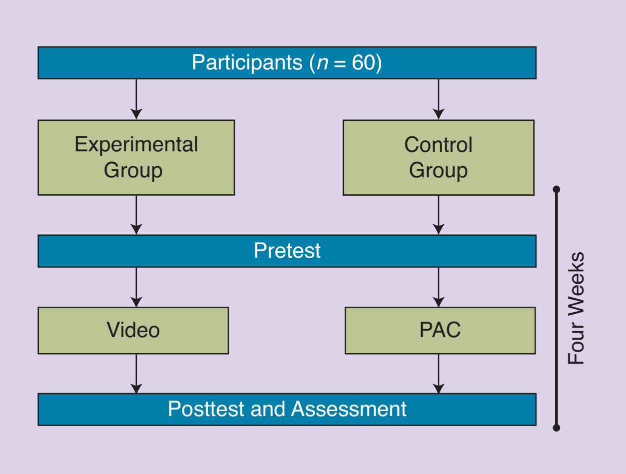

FIGURE 8. The study design and participant assignment to experimental groups.

FIGURE 9. (a) The setup of the experimental group. (b) An on-screen view of the dance movements.

PROCEDURE

All participants were brought into the lab for a pretest of their dance skills. The assessment was made by two professional Tujia folk dance teachers with an evaluation scale on dance. During the following four weeks, participants in the control group were brought back to the lab twice a week for a 2-h practice following the video. Participants in the experimental group were brought back to the lab twice a week for a 2-h-long practice with the PAC. The professional dance teachers then assessed all of the participants' dance skills after corresponding interventions of the two groups. They were blind to the practice groups of the participants.

During the intervention, the participants were asked to pretend that they were learning the waving dance in class by following the choreographer. The experimental process is shown in Figure 8. The participants in the two groups were learning in different places and at different times to avoid mutual influence, but their experiment environments were similar. We can see the setup for the experimental group in Figure 9, in which the PAC is run on a computer and shown on the screen in front of the user. The experimenter left the room while the participants were learning the dance, and the participants were asked to leave the room once their time was up. Participants were told to practice in their own way but that they should interact with all of the modes in the PAC. Camera 1 recorded the process of the experiment, while camera 2, built into the Kinect, recognized and captured the dance movements of players to help the PAC evaluate the movement of the player instantly. Camera 1 recorded the dance process with video, and camera 2 recognized movements of the participants.

MEASUREMENTS

The participants were pretested after grouping to make sure their dance foundations would make no significant difference. The dance used for pretesting was different, however, from the dance used for the formal test. The professional teachers used the evaluation scale to grade participants' performance during the pretest. Then participants learned the Tujia hand-waving dance in different ways following the methods of Figure 8. In addition, the measurement of dance performance and satisfaction was carried out using the dance evaluation scale at posttest as well as the satisfaction scale at the end of the practice of the two groups.

The effect of learning is mainly reflected by the dance score measured before and after the intervention. As a traditional sport of the Tujia people, the moves of the hand-waving dance come from the labor of production, daily life, and wars. The evaluation rubric has been revised on the basis of the dance performance evaluation rubric made by Hsia et al. according to the features of the hand-waving dance, which mainly focused on the choreography, technical skills, performance skills, and rhythm [16]. The revision includes the description of choreography and technical skills. As shown in [17], the description of the code of rating levels on hand-waving dance performance can be divided into four aspects. Furthermore, the code of rating levels on hand-waving dance performance was designed and revised by the professional folk dance professors with reference to the five-point Likert scale. The results of the consistency analysis on the code turn out to be good (kappa $= 0.45$, $p = 0.000 < 0.05$), indicating that the two teachers were largely consistent in the understanding of the code and the evaluation of the dancers.

Because the device in the PAC is handy and inexpensive, it can be used to research and develop a personal dance instructor.

Emotional acceptance is shown as the outcome of the satisfaction scale, which has been revised on the basis of the online learning satisfaction scale made by Wang, combined with the features of the game-based learning system PAC [18]. The satisfaction scale is shown in [19]. The reliability was evaluated by the internal consistency of items in the scale representing each factor using Cronbach alpha. The 12-item satisfaction scale had a reliability (Cronbach alpha) of 0.808, exceeding the minimum standard of 0.60, which showed good reliability and internal consistency.

According to the single variable control principle, the experiment tools in this study include the dance learning system, PAC, teaching video containing the same content as the PAC, pretest and posttest of the dance performance evaluation scale, and self-evaluation of the learning satisfaction scale.

RESULTS

In this section, we describe the different influences of the PAC and traditional video on the waving-dance learning performance and learning satisfaction of the participants.

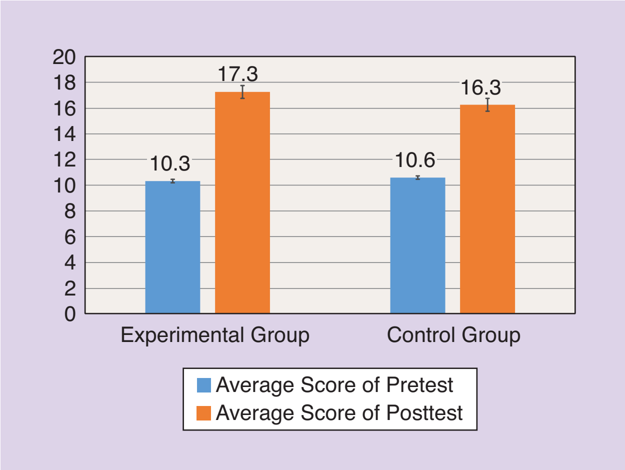

FIGURE 10. A comparison of the average scores of the learning performance test.

It was found that PAC and video instruction have a different effect on participants' dance learning performance and satisfaction.

LEARNING PERFORMANCE

Figure 10 shows the comparison of the average scores of the waving dance learning performance test between the experimental group and the control group. The dancers' performances were evaluated by the professional teachers using the code of rating levels for the hand-waving dance. The pretest average score of the experimental group was 10.33, and the average score of the control group pretest was 10.62, indicating there is no significant difference between the dance foundations of the two groups ($t = 0.001$, $p = 0.334 > 0.05$).

It is obvious that the posttest scores of the experimental group ($M = 17.27$, $SD = 1.335$) were higher than their pretest scores ($M = 10.33$, $SD = 0.488$). According to the t-test results, this demonstrated a significant difference ($t = 8.06$, $p < 0.001$). The posttest scores of the control group ($M = 16.27$, $SD = 0.799$) were also higher than their pretest scores ($M = 10.62$, $SD = 0.507$). A significant difference is apparent according to the t-test results ($t = 9.433$, $p < 0.001$). Next, the posttest scores of the experimental group ($M = 17.27$, $SD = 1.335$) were higher than the posttest scores of the control group ($M = 16.27$, $SD = 0.799$). According to the t-test results, this also showed a significant difference between the dance performance in the posttest of the two groups ($t = 3.623$, $p < 0.001$).

LEARNING SATISFACTION

After the intervention, the satisfaction scale was used to investigate the satisfaction level of the two groups. The interview was carried out to provide an explanation for the satisfaction scale results and suggestions for the dance learning method. Figure 11 shows the test results of the two groups.

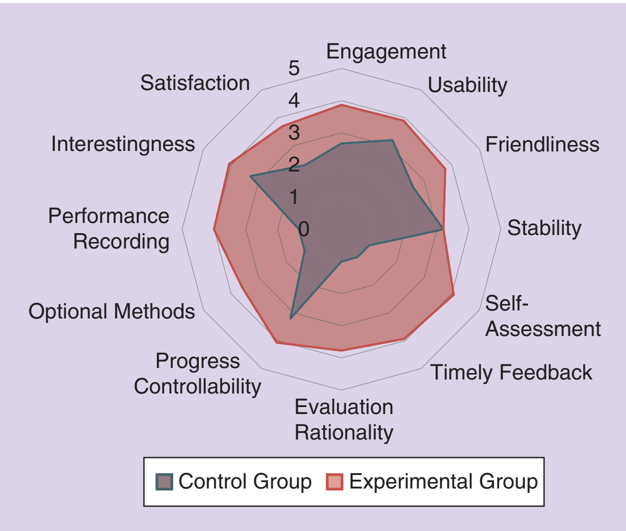

FIGURE 11. The average score on the satisfaction scale for both groups.

The red area in Figure 11 shows the outcome of the experimental group survey. The experimental group's evaluations on engagement, usability and user friendliness, self-assessment, timely feedback, and progress controllability, as well as interestingness, are higher than those in the control group and show a good response from participants in the experimental group, according to the results. The average score of each of those items is higher than 3.76, which is close to the agree dimension. The stability, optional methods, and satisfaction are still to be developed, though these evaluations are higher than the control group, too. The blue area in Figure 11 is the outcome of the control group's satisfaction scale. Though the usability, stability, progress controllability, and interestingness are relatively higher than other aspects, the average score of each of those items is less than 3.3, which is acceptable.

According to the interview of the experimental group, some participants felt that the PAC is very interesting and worth popularizing further to promote dance education. They suggested that the PAC be used in dance classes and experience centers for the hand-waving dance to enhance the experience and interest of students and tourists who are interested in the dance. Some participants were greatly involved in dance learning, and they thought the PAC could help them concentrate on their movements during dance practice. Because the device in the PAC is handy and inexpensive, it can be used to research and develop a personal dance instructor.

DISCUSSION

The game-based learning system PAC is researched and developed in this article. It provides a new method to evaluate and improve learners' performance of the hand-waving dance, aimed at the protection of the Tujia hand-waving dance culture. The evaluation of the PAC system is based on the experimental results of the dance performance and satisfaction compared with traditional video instruction. It was found that PAC and video instruction have a different effect on participants' dance learning performance and satisfaction.

As for the dance performance, the results showed an improvement in performance for those who used the PAC to practice the hand-waving dance, indicating the game-based learning system is effective in dance learning. According to the paired-samples t-test results, the dance performances of participants in both groups improved compared with the pretest, demonstrating a significant difference. The result can be explained by the theory that all participants invested time and effort into learning and improvement. The findings of the study are that the PAC is more effective in dance learning improvement according to the statistical results, demonstrating a significant difference between the two groups. One possible explanation may be that the experimental group used the PAC to control the learning system, and the PAC combines game elements and dance movements while practicing the hand-waving dance. The motion-sensor interaction method reinforced their memory and enhanced the learning enjoyment, which made them more involved in the practice of dance movement. The instant feedback from the PAC shown on the system interface helped users adjust their corresponding joints to improve the correctness of their dance learning. As for the satisfaction scale, the experimental group was better than that in control group, meaning that PAC satisfied the users' needs in dance learning while the traditional instruction video did not.

CONCLUSION

Just like the Kinect's motto, "You are the controller," PAC makes it possible for every dancer to be his or her own controller. It is the first thing that digitizes and evaluates the Tujia hand-waving dance in 3-D data, combining the technology of the Kinect sensors with protection for the traditional hand-waving dance. This article is among the first that focuses on the automatic evaluation of students' dance performance based on their captured movements. It proposes a novel approach for dance movement data analysis evaluation of the learner's performance qualitatively and quantitatively using the method of game-based learning. Moreover, it introduces the dance movements database for evaluation and protection of the Tujia hand-waving dance. Future research can concentrate on expanding the dance movements database to enlarge the application of the PAC to other motor skills learning, such as tai chi and Chinese kung fu.

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