Dance Training Tool using Kinect-based Skeleton Tracking and Evaluating Dancer's Performance

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Abstract. In this preliminary work, we propose a system prototype for Thai Dance training. This paper considers the problem of teaching traditional dances from Thailand. This is particularly useful given the lack of teachers and tools for teaching dances. In order to build a software tool helping people learn Thai dances, the main problems are i) how to represent the dance gestures and movements of the dance to teach, ii) how to display it for the learner and how to rate the performance of the learner and provide him useful feedback. Fortunately, Natural User Interfaces (NUI) enables users to interact with a system in a natural and intuitive way. For instance, a user can interact with the system by his body through postures and movements. In this study, we developed a working prototype of a system teaching users traditional Thai dances. The system requires Kinect-based device to enable real-time skeleton tracking. For the reference postures/movements dataset, we collected dance movement from experts by Motion Capture System and used the collected data to represent the dance in the system. Moreover, the system is designed such that it rates the user's performance and provides helpful and real-time feedback to the user.

Keywords: Microsoft Kinect, Skeleton Tracking, Thai Dance

1 Introduction

The work reported in this short paper is carried out in the framework of a European research project called AniAge dealing with High Dimensional Heterogeneous Data based Animation Techniques for Southeast Asian Intangible Cultural Heritage Digital Content. The AniAge Project aims to tackle challenging problems such as archiving and reproducing style-preserved intangible cultural heritage (ICH) contents. The overall aim of AniAge is to develop novel techniques and tools to reduce the production costs and improve the level of automation without sacrificing the control of the artists; in order to preserve performance arts related ICHs of Southeast Asia.

Southeast Asia is one of the most rapidly growing regions in the world. The coastal states have a population of around six hundred millions and are very rich with natural and cultural resources. The United Nations Educational, Scientific and Cultural Organization (UNESCO) now lists many of the living traditional art forms in these countries as intangible cultural heritages (ICH) needing preservation. Examples include traditional dance and local operas.

Thailand is located in Southeast Asia and it is one member of the AniAge project. This country is very rich with cultural and performance arts. Especially, the dramatic arts have played important role in Thailand. Dramatic arts in Thailand are generally transmitted from the ancestors for next generations orally. The curriculum of education in Thailand enforces students to study Thai Dance, which is one of dramatic arts. Unfortunately, shortage of teachers of traditional Thai dances and lack of alternative tools for helping student to learn Thai dances don't allow reaching such an objective.

In this work, we deal with three main issues. The first one aims to represent the postures and movements of some Thai Dances in the training system. We study some of data collection process and represent the postures and movements with 3D characters. In the second, we study the problem of evaluating and rating the user's performance in real-time through skeleton tracking with Microsoft Kinect device. We developed this software prototype using Unity, which a popular tool in game development industry. The third issue is how to provide useful feedback for users such that they can efficiently improve their performance.

This paper is organized as follows: In section 2 we briefly describe a Thai Dance Data set. In section 3 we describe the dance data collected from Microsoft Kinect and some information about mapping the captured data with 3D models. In section 4 we provide Thai Dance Training Tool System Architecture. In section 5, we describe the system prototype with some of user interface and how to evaluate dance performance. Finally, in section 6 we proposed some future work of this the system.

2 Thai Dance Dataset

The movements in Thai Dance are motion gestures imitating nature for meaningful use. The gestures need the whole body to perform. The motion gestures play the same role as words such that the audience can understand. Thai Dance have multiple types of motion gestures. For example, gestures may express pronouns; "I", "You", "We", "Go", "Come", gestures may express actions; "Standing", "Walk", "Sit", "Pray", gestures may express emotions; "Glad", "Sad", "Angry", "Love", "Cry", and some gestures are used for imitating animals like "Bird", "Fish", "Horse" and "Elephant".

In this work, we used a dataset from Thai Dance experts performing a popular Thai dance including Northern Thai Dance and Central Thai Dance. This involves recording Thai Dance captured with various systems, including Microsoft Kinect sensors. The dataset includes records of 2 experts Dance (a male and a female) performing Thai. In our prototype, the dataset is composed of 11 gestures: Go In (Come), Go Out (Go),

Happy, Love, Sad, Shy, Smile, Walk, Angry, Laugh, Cry and 2 songs which we captured using Motion Capture System making use of 42 markers set on the performers' bodies.

3 Microsoft Kinect

The Kinect motion controller technology, developed by Microsoft Corporation, tracks the skeleton of a person standing in front of the device. It has a set of IR and RGB cameras. The IR cameras are used for sensing the skeleton and hence the body postures irrespective of the color of the performer's dress or distance from the camera [1]. Skeleton data contain 3D position data for human skeletons. Each joint position in the skeleton space is represented as three coordinates (x, y, z). The skeleton space coordinates are expressed in meters [2]. The real-time skeleton tracking using OpenNI SDK provides among others, a high-level skeleton tracking module, which can be used for detecting the captured user and tracking his/her body joint. More specifically, the OpenNI tracking module produces the positions of 17 joints (Head, Neck Torso, Left and Right Collar, L/R Shoulder, L/R Elbow, L/R Wrist, L/R Hip, L/R Knee and L/R Foot), along with the corresponding tracking confidence [3].

3.1 Kinect in Education

Hui-Mei J. explores the potential of Kinect as interactive technology and discusses how it can facilitate and enhance teaching and learning. Kinect is examined in terms of its affordances of technical interactivity, which is an important aspect of pedagogical interactivity. As it utilizes gesture-based technology, Kinect can support kinesthetic pedagogical practices to benefit learners with strong bodily-kinesthetic intelligence. As far as a teaching tool is concerned, due to the multiple interaction types it supports, Kinect has the potential to enhance classroom interactions, to increase classroom participation, to improve teachers' ability to present and manipulate multimedia and multimodal materials, and to create opportunities for interaction and discussion. In addition, students can utilize the bodily information gathered by Kinect with software programs to create highly interactive multimedia works [4].

3.2 Kinect for Teaching Dance

Emiko C. et. al. presented a study comparing a dance instruction video to a rhythm game interface. This research explores the player's perceptions of their own capabilities, their capacity to deal with a high influx of information, and their preferences regarding body-controlled video games. The results indicate that the game-inspired interface elements alone were not a substitute for footage of a real human dancer, but participants overall preferred to have access to both forms of media [5].

Zoe M. et. al. proposed the Super Mirror, a Kinect-based system that combines the functionality of studio mirrors and prescriptive images to provide the user with instructional feedback in real-time. In this study, they developed a working prototype of their system, which records ballet movements (also called "positions" and "poses") and contains step-by-step illustrations of individual movements, captures live motion. The fundamental purpose of the Super Mirror is to render the useful features of mirrored reflection and modeled instruction in a clear and informative way [6].

4 Thai Dance Training Tool System Architecture

The system diagram of Thai Dance Training Tool, in our proposed system is shown in Figure 1. The end-user (player or learner) can interact with the system to be installed on the user's computer or available on-line. The user's computer is equipped with Microsoft Kinect. Figure 1 shows the architecture of the proposed system. The optical Motion Capture system is used to capture the movements of the Thai Dance expert performer. The motion data is then stored into a database. For each posture and gesture of a dance to teach, we captured some samples from the expert performer. The database represents the reference motion data of the dances. Such reference samples are used to rate the learner's performance using posture and motion recognition techniques. When the end-user performs in front of his Kinect device, his postures and movements are displayed on the screen while the system analyzes the performance to provide useful feedback.

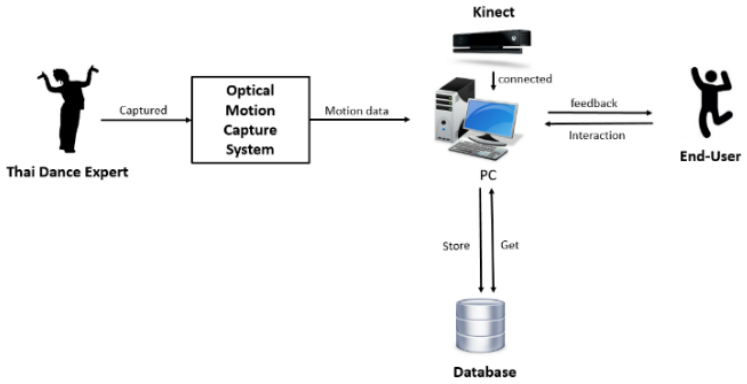

Figure 1. Thai Dance Training Tool Architecture

Note that the reference dataset of postures and gestures is captured only once and offline. As said earlier, in our system, we rely on 2 Thai dance experts to perform the motion of Thai traditional dance. We captured 11 gestures since the experts teaching Thai dance in the college.

Figure 2 shows the motion capture system and Thai dance expert while they were performing and the system was capturing.

Figure 2. Capturing Thai Dance Expert Motion

5 System Prototype

We proposed a system prototype for training people Thai dance and we have implemented the interactive training tools system. In our application, the dataset contains two types of Thai dance (Central Thai dance and Northern Thai dance) as shown in Figure 3. The graphical user interface of the system includes:

- Main menu (dance type choice): When a user chooses the type of the Thai dance he wants to learn, the gestures selection page shows 22 motion gestures and 1 song as shown in Figure 4.
- Gestures menu: When a user selects the gesture, the system shows the reference 3D model captured using the motion capture system and the learner's model on the right side. The user should try to match the pose on the left, then the system provides performance feedback for user. Moreover, user can play gesture animation before performing as shown in figure 5.

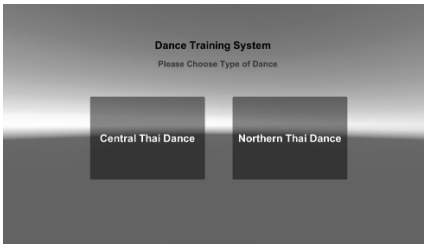

Figure 3. Main Menu

Figure 4. Gestures selection page

Figure 5. Reference Model and Learner's Model

In addition to the user interface, the prototype involves reference Thai dance posture and gesture samples captured from the experts. When learning, the system tracks the skeleton of the learner in real time and compares it with the chosen gestures or postures to learn. In order to do such comparison, we have reference model on the left side for the 3D model which have each joint and for each joint can be connected and make the bone for the comparison we use the angle of each bone. We compare the reference bone with the Learner's model bone in real-time and calculate the difference each bone. We supposed to max angle different is 90 degree. For difference degree of each bone, we summarize overall difference angle and give grade for Learner. Moreover, the prototype can show list of each joint which low performance for Learner to improve their dance performance.

Note that the result of the comparison is a global score ... which we graphically represent in colors and text message (such as: Goof, bad...). In addition, in order to point out the exact p arts of the body where the performance went wrong, the concerned joints of the skeleton are highlighted and displayed directly on the screen.

The proposed prototype has been successfully implemented and tried in realistic conditions on the two captured Thai dances by some volunteers. The first results are very encouraging but there is need to assess empirically our system on a sample of learners and a wide range of dances in different conditions.

6 Conclusion and Future Work

The work reported in this short paper results from preliminary works in the AniAge project dealing with Asian intangible cultural heritage digital contents. This paper presented an interactive training prototype for representing basic postures and gestures of Thai dances. We provide the system description including data collection, learner's performance evaluation and providing feedback. In future works, we will address all the remaining issues, in particular how represent complex gestures, how to evaluate user performance for a whole performance and how to improve performance the rating and feedback. We also plan to use abstract descriptions of dances instead of motion data captured from dance experts. For instance, it would be very interesting and challenging to use dance notations (ex. Labanotation) as reference models and compare the learner's performance with such notations.

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