Visualization of Folk-Dances in Virtual Reality Environments

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Abstract Cultural tourism helps with the preservation or revival of culture and traditions. It includes many different attractions including performing arts and festivals. Since folk dances are part of cultural heritage and their preservation has major importance, this paper presents applications for visualization and learning of folk dances. Based on different interactive motion capture technologies, new approaches for observing, analyzing and learning dances, and movements in general, have been created. A popular approach for learning purposes is to record a professional dancer using motion capture technologies and then visualize the dance. Users are supposed to watch and imitate the teacher's performances. In this paper, a similar approach is proposed, where users can choose the dance they want to watch through an interactive interface, and they can see the teacher's avatar performing the chosen dance. At the same time the avatar of the user can be seen, and users can track their performance. For recording teachers' and users' dance performances, an optical motion capture system, namely OptiTrack, has been used. The dance performance of the teacher is pre-recorded off-line, while users' performance is recorded and streamed in real-time to the application. Through the interface, users can choose to watch different folk dances and different ways of visualization for learning purposes.

Keywords Folk dances · Motion capture · Visualization · Virtual reality

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1 Introduction

Connecting culture and tourism can significantly help the development of any city or country. The most important resources a city or region can offer to tourists are tourist attractions. Tourist attractions include natural, cultural manifestations, folklore, contemporary buildings and events [1]. Cultural tourism addresses the experience of tangible and intangible cultural heritage [2]. Intangible cultural heritage (ICH) includes traditions or living expressions inherited from our ancestors and passed to our descendants [3]. Folk dances are part of ICH and their preservation should be important for every nation and ethnicity. In computer science, digitization and visualization of folk dances are an increasingly active area in computer science [4].

Folk dances are passed from one generation to the next and they are usually taught in person, imitating the teacher's dance moves. Currently, different types of digitization and visualization of dances are available [5, 6, 7] and can help towards the preservation and dissemination of folk dances. Digitization can also include audio, video or even 3-D sensor recordings but may also include additional motion representations e.g. a semantic description of dance or even a computer animation. Motion capture is a process of digital recording motion of a real-time object, usually a human performer [8]. Different systems can be used, such as optical systems with active or passive markers, magnetic, mechanic [4, 9, 10]. In this work, an optical motion capture system with passive markers was used. These systems can offer high precision for captured data, which is a significant advantage.

The process of digitization is not enough itself to pass the folk dances to the next generations. There is a need to visualize captured dances in order to make it available to the wide public. Currently, popular ways of visualization are serious games and gamification techniques as well as virtual reality (VR). Serious games are designed for a different purpose than just entertainment and can be used in various application domains, e.g. in teaching, since they can promote training, knowledge acquisition and development of skills through interactive and immersive activities [11], education [12] as well as cultural heritage [13]. The application for the visualization of folk dances described in this paper has been developed for the Terpsichore EU project [14].

In this paper, an interactive application in VR is presented for visualizing and learning folk dances in VR environments. The application is currently under development. Captured data are used for the animation of a three-dimensional (3D) virtual character that represents a dance teacher. Professional dancers were captured in order to capture a digital representation of specific folk dances. Applications like this one can be useful, not just for learning purposes, but to demonstrate different folk dances to different audiences, including tourists. For users (learners or tourists), an interactive interface in VR is provided. Using dedicated VR controllers, users can select between different folk dances (that have been previously captured). They can also choose to visualize either a male or female performance of the dance. The application provides personalized visualization for each user, i.e. they can adjust the view according to their needs. After watching a dance, they can try to reproduce professionals' dance movements.

2 Related Work

Many different applications for dance visualization and dance teaching have been proposed in the literature. In [15] a learning framework for folk dances was proposed. Dance teachers and students can use the 3D platform and interact with the animated dancers. Students observe teachers' performance and they can interact with the platform to better understand dances. Another approach for teaching dances is to use virtual environments, such as the cave automatic virtual environment (CAVE). In this approach, the projector's screen is placed between three to six walls of the room-sized cube [16]. The user observes and imitates teacher's movements and feedback is provided to the user [17]. Game-like applications also can be found in the literature for teaching dances. Several similar applications are proposed in [11, 18, 19]. In these applications, a game interface is available for the users. The avatars of the teacher and the user are displayed, and the user's movements are streamed to the application. Feedback with score and comments is provided to the user and if the performance is not good enough (i.e. the score is low), it is not possible to move to the next level.

In a similar approach [20], users are captured during the performance and avatar that visualizes their motion uses fused input from multiple sensors. Motion analysis and fuzzy logic are used for the evaluation of users' performance. Low-level skeletal data and high-level motion recognition probabilities are used as inputs for the two-level fuzzy system. Skeleton information is used for generating articulated human movement in [21]. In this work, pairs of a human skeleton as motion embedding and a single human image as appearance are used to train a GAN model to generate novel motion frames. Generating human movements is a very challenging task. Movement is continuous, highly dimensional, and fundamentally expressive. An approach for dance movement generation from audio is presented in [22]. An artificial neural network learns to synthesize dance movements for a given audio track in real time. The system was tested on a small database, but the audience can also provide their own music to interact with the avatar. An auto-conditioned Recurrent Neural Network for synthesizing highly complex human motions, including dances, was proposed in [23]. In [24], the authors combine insights from musical onset detection and statistical language modeling, to designed and evaluate a number of deep learning methods for learning to choreograph. More specifically, Dance Dance Revolution (DDR) is a rhythm-based video game, where the player performs steps on a platform, in synchronization with music following on-screen step charts. The goal of this work, namely Dance Dance Convolution, is to produce a new step chart from a raw audio track. Thus, the task of learning choreography is introduced, and neural networks are used to solve two subtasks: deciding when to place steps and which steps to select. VR applications can help the user to explore, learn and understand cultural heritage in a more immersive way. The concept for designing content of traditional dance based on interactive storytelling has been presented in [25].

Our approach is similar to mentioned work in a way that user's and teacher's avatars are streamed to the application and users can view both avatars at the same time. However, the application presented here is in VR and extends some functionalities. Except the users can choose between different dances, they can also choose between different avatars and different environments. Furthermore, all the dances have been synchronized with music and users can adjust the speed as they have playback and they can enable trail control.

3 Dance Recording Procedure

Motion capture is the process of recording moving objects or people. In our case, it is the process of recording the dance movements. In this work, an optical motion capture system with passive markers, namely OptiTrack, has been used. Passive markers used for motion capture are placed on specific predetermined positions on the body. More information about how to use the OptiTrack system for folk dances can be found in [8]. Five folk dances from Austria. Slovakia and the Czech Republic have been recorded in the Human-Computer Interaction Laboratory (HCI Lab), Masaryk University, Czech Republic. Dances were performed by professional dancers (a pair of dancers, male and female, was used in each recording). The recording procedure has three phases. First, the dance was performed by a single dancer (male or female) alone. The dancer was wearing a suit suitable for digital capturing during the recording. The second phase was to record the male or female performance of the dance performed within pair. The dancers danced together, but just one dancer was wearing a suit for digital capturing. In the third phase, dancing was performed again in pair, but both dancers were wearing suits. Suits are non-obtrusive, and they do not restrict freedom of the dancers' movements. All the dances were performed with corresponding music. Several recordings of each performance were made. In general, it is a good practice to repeat recording several times, when optical motion capture systems with passive markers are used for motion capture. Some errors and markers' occlusions were not obvious during recording and were discovered later. Recorded data were saved and then post-processed using Motive [26], although other software for editing data, such as MotionBuilder [27] can also be used. Motive offers different ways of interpolation for gaps in markers' trajectories. Interpolation can be a good solution if the gap size is relatively small. Also, low-pass filters with adjustable cutoff frequency were used for smoothing the data and unlabeled markers were deleted. After editing, data has been exported from Motive and imported into Unity3D [28], for visualization in immersive VR.

4 Visualization of Dances

Visualization and presentation of dances and human motion, in general, can be done in different ways. Video, VR environments and game-like applications (3D game environments) are currently the most popular. Usually, dances are visualized in applications for learning purposes. The interface of the application used for learning purposes should be simple, intuitive and interesting for the user. Since it is an application for learning how to dance, users should not spend too much time on learning how to use the application.

The application presented here is a VR application with an interactive interface. Using HTC Vive Headset and controllers, users interact with the application. HTC Vive Headset is connected to the computer and may be obtrusive for the user and limit the movements freedom, but user testing in the future should help us to investigate this problem. The software was developed in Unity 2018.2 using C# scripts. The recorded data are visualized by animating a virtual 3D character [29]. Figure 1 illustrates the two avatars: user's avatar (male) is following the professional's avatar (female), while both are performing the same version of the dance. Users can choose for the professional's avatar between three avatars: male, female or generic. Clothes and environments can play an important role in folk dances, e.g. in order to demonstrate surroundings from the past. Folk dances are often associated with traditions of groups that used to live in rural locations. In some cases, rural areas are now urbanized, but people are still interested in their traditional dance heritage. On the other hand, folk ensembles keep the folk dances tradition alive in both urban and rural areas. Performing folk dances in urban areas helps to ensure the survival of folk dances. The idea presented in this work is to use VR for recreating different rural, urban and/or modern environments that we can find today and place dancers' avatars there. In this way, we aim to bring folk dances closer to the users and attract new audiences such as young people or the elderly. Figure 2 shows an avatar of the professional dancer during the performance of one

Fig. 1 Female and male avatar used for animations

Fig. 2 Visualization of folk dances in rural environments

of the recorded folk dances in a rural environment. Through an interactive interface user can choose between different VR environments for folk dances.

On the scene, two avatars can be visualized. One is the pre-recorded animation of the professional dancer and the other is the user's avatar. Users should wear a suit and their performance is streamed from Motive to Unity in real-time (the lag during the streaming is not noticeable). All the dances are synchronized with the audio. Using the controller's touchpad, it is possible to change the animation speed, while, at the same time, the speed of playing music is also changed, since the animations are synchronized with the corresponding music. A user can stop and resume the dance, play the track forward or even backward. The dance can also be examined from different view angles. Just watching the dance, without having the intention to learn it, might be useful for tourist applications. Using proper VR equipment, e.g. any kind of headsets and controllers, tourists can get an immersive experience of the dancing performance in VR and thus familiarize with the culture and tradition of the place in a different way. Also, the desktop version of the application, presented in [8], can be used to present dances to the visitors that are not interested in trying VR. Using screens tourists can stop by and watch the dances.

5 Conclusion

The primary goal of the paper was to present a system able to visualize dances recorded using a motion capture system, to be used for learning purposes. An avatar, animated with the recording of the professional dancer, can demonstrate the dance to the users as well as the corresponding footsteps. By observation of this avatar and imitating the dance or following the footsteps, users are able to learn how to dance a folk dance available in the application. The application can also be used to just watch the dance. An interactive interface is provided to the users for a better experience. Through this interface, users can adjust the view of performance to their needs. Corresponding audio clips that are synchronized with the 3D animation were added to the application. User testing of the application is the next step for future work. The main goal is to evaluate learning process and improve the application according to user's experience. By using various algorithms for comparison, i.e. dynamic time warping (DTW), the user's performance will be compared with the performance of the professional dancer. Since the current version of the application provides no feedback to the user, it is very important to provide such feedback. Avatar poses should be compared in order to detect and show to the users their mistakes, so as to help them improve their dancing skills. Future work will also include improvements of the user interface, to make it easier to use. The recorded dances will also be segmented into sub-sequences, so that particular parts of the dance or dance figures could be used for learning.

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