Digitization of Cypriot Folk Dances

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Abstract. In this article an initiative to preserve the Cypriot folk dance heritage is reported. The project aims to create a publicly accessible digital archive of folk dances that does not only include video recordings, commonly used to document dance performances. In addition to rare video material held by local cultural institutions, state-of-the-art motion capture technologies are utilized to record and archive high quality motion data of expert dancers performing these traditional dances. Apart from the goal of preserving this intangible cultural heritage by digitizing it, the project is interested in increasing the awareness of the local community to its dance heritage. To achieve this a 3D video game for children is developed to teach these folk dances to the younger generations.

Keywords: digitization, folk dances, motion capture, educational games.

1 Introduction

Cyprus has a rich history and diverse tangible and intangible cultural heritage, which in recent years has been painstakingly recorded, curated and remediated. Similar to literary and visual arts, performing arts and especially folk dancing is an important part of the cultural heritage of the island. However, being intangible cultural heritage, folk dancing cannot be easily preserved and its dissemination to the younger generations has become challenging for the few cultural institutions offering lessons. Currently, the vehicles for preserving and propagating folk dancing on the island are primarily the dance teachers and some of the senior citizens, as well as rare video recordings from local festivals, weddings and other social gatherings. This project is a collaborative effort of the VR Lab of the University of Cyprus[1] and the Cultural Workshop Ayion Omoloyiton[2]. With the former institution providing the technical expertise and motion capture facilities and the latter making available rare dance heritage video recordings and committing expert folk dancers to perform for the purposes of motion capture. The project aims to digitize, record, archive the Cypriot folk dance heritage and disseminate it to the wider local community and serve as a reference for related research activities.

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[1] http://graphics.cs.ucy.ac.cy
[2] http://www.politistiko-ergastiri.org

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Digitization technologies such as video and audio recording provide the primary means of capturing a live dancing performance and coupled with other methods of recording and documenting dances, such as Labanotation, form the basis for mitigating the risk of these dances disappearing. However, in recent years human body motion capture and tracking technologies have become both robust and more affordable, effectively making it possible to record the motion of expert dancers in real-time and in three dimensions. This motion can then be digitally stored, reproduced, analyzed and processed, thus enabling researchers and practitioners to study, research and understand better the gist of these dances.

There have been many scholars and performers, such as Merce Cunnigham and Lisa Naugle, who have extensively worked with motion capture technologies in dance and choreography since the late 90s. Despite the volume of research for digitizing and preserving dance data, there is hardly any database available online with dance motion capture data available; even the European Commission-sponsored knowledge-sharing platform Europeana does not appear to currently refer to any such data. Furthermore, the Cypriot folk dances have never been systematically recorded and archived using motion capture technologies, and therefore one of the goals of this project is to develop the first high quality digital archive of this kind in collaboration with local cultural institutions, with an outlook to providing a platform for furthering this practice elsewhere.

The second goal of the project is to increase the local population's awareness of its folk dance heritage by introducing a novel dance teaching system that anyone can use at home and thus enhance the chances of these dances sustaining the test of time. The current trend in scientific research regarding dance teaching systems is to use 3D Virtual Reality to coach users through the necessary body postures and moves by presenting them a virtual avatar that performs the dance using pre-recorded motion templates. The users are motion tracked, usually in a laboratory environment, and should then imitate the movements of the 3D avatar, often providing some form of feedback, either textual or visual. However, high quality motion capture systems are not available to home users. Instead there is currently a surge in use of less accurate inexpensive gaming motion sensors, such as Microsoft's Kinect. In this project a video game controlled via Microsoft's Kinect sensor has been developed which users can use in their living room to learn dancing traditional Cypriot dances. While the underlying idea of coaching users through dancing movements is not new, the use of the Kinect sensor poses significant new challenges in human motion analysis, since its motion capture and tracking capability is inferior to that of professional motion capture systems and therefore it becomes difficult to determine the user's performance in imitating an existing dancing motion.

In the next section we will briefly review related efforts to folk dance preservation and propagation using Virtual Environments. In Section 3 we describe our Motion Capture and 3D Virtual Reality facility and the methodology of capturing and archiving folk dances. In Section 4, we describe the dance training video game and the algorithms used for motion matching. Finally, in Section 5 we summarize our experiences and outline the future work.

2 Related Work

In recent years the attention of a number of scientists and media artists has been drawn to utilizing existing, and developing new, technologies for the preservation and propagation of Intangible Cultural Heritage [1]. On the one hand, motion capture technologies have shown promise in the preservation of dancing performances, alongside video recording, while on the other hand, Virtual Reality has become indispensable from dance training software systems that are popular among end-users (i.e. in the form of 3D games). According to [2], there are several advantages of motion capture over other methods (e.g. video), especially the ability to reconstruct moments in a dance that cannot be easily identified in a film, as for example in the case of complex partnering moves. The primary reasons for motion capture not becoming a mainstream tool for recording dance performances are the relatively high cost and the limited availability of quality motion capture facilities to professional dancers. However, as recently the costs decreased inversely proportional to the quality of these systems a need for developing methods and tools to archive and store this motion capture data alongside other forms of dance recording data, has become apparent. Motion data have been successfully used to visualize, edit and compose choreography in conjunction with dance notation [3].

Capturing and organizing this motion data in a systematic manner enables a multitude of applications to be developed. Golshani et al. [4] presented a multimedia information system that can be used to store a variety of dance-related data (e.g. photographs, audio, video, motion data, etc.), and proposed strategies for feature extraction and analysis of this data, useful for cross cultural dance studies. More recently, Kim [5] presented ChoreoSave, a prototype of an online digital dance preservation solution that identifies what components comprise a dance work and how such components can be represented using existing software.

Apart from the digital data archives that are crucial for the preservation of dances, motion data can be used to reconstruct performances for training purposes. One of the challenges in virtual dance training is to recognize the user's motion, to either provide feedback, or adjust the parameters of the virtual world in response. Motion matching in dancing applications can be achieved by establishing the similarity of body postures between two motions. Motion graphs [6] is a widely used technique for matching motions using the Euclidean distance between joint positions or angles and has been primarily used for motion synthesis tasks. In contrast, Qian et al. [7] based their dancing system on gesture recognition using the Mahalanobis distance between joint angles to extract and match gestures between motions. Deng et al.[8] presented an interactive dancing game which uses a technique based on self-organizing map (SOM) clustering of body parts. Using this algorithm the player's motion is recognized and a virtual dancing partner is animated appropriately, from a preset of motions, in response. Chan et al. [9] proposed a self-training dance system that features a virtual teacher and provides visual feedback of errors made by the player.

In [9], a user study has shown that the proposed self-training dancing system does improve the skills of the players. Charbonneau et al. [10] conducted a study to determine if virtual interfaces alone are satisfactory for the users. They found that users of dancing systems preferred to have to their disposal both a virtual representation, as well as real footage of their performance.

3 Digital Preservation of Cypriot Folk Dances

To ensure folk dances are sufficiently well documented, recorded and archived, apart from text, drawings, choreographic notation (such as Labanotation and Benesh Movement Notation) and video, it can be tremendously useful to capture the human motion itself, directly from expert dancers. This does not only safeguard the survival of the complete motion objectively; it allows reusing it to study or teach this, usually structured or complex, motion. Even video recording a dance would require the use of multiple cameras to mitigate occlusions. It would then be necessary to use the footage obtained from the multiple fixed viewpoints simultaneously to study the motion of the performer, however this method would still be subjective and prone to erroneous interpretation of the displayed motion. Despite the limitations each of the alternative ways of recording a dancing performance, these other means of recording dances cannot be phased out in favor of the new motion capture technologies; quite the opposite, the motion capture data is a complementary data channel that should be used in conjunction with text, video and choreographic notation systems. Some of this data may have significant cultural and historical value too, for example as in the case of the decades-old video material held by the Cultural Workshop Ayion Omoloyiton.

In this project an effort to systematically record and digitize Cypriot folk dances is initiated by designing a digital folk dance archive, which can easily be enriched with new data over time and curated by experts. The approach taken involves designing a relational database schema to structure the information within the archive, which should encompass all types of data associated with dances. The archive has to be scalable, so that data and metadata, such as motion capture and video data can be accumulated as they become available. It should also provide for archiving existing material irrespective of the availability of motion capture or video data. The relational database forms the backend of the archive, while an online web portal[3] enables public access to the data of the archive, as well as editing capability to privileged users.

As there is currently no standardized method of dance recording and archiving and there are several ongoing efforts, e.g. that of the Dance Heritage Coalition, we are keen to develop a simple schema that can be readily used to record those aspects of the motion captured dances which will allow us to disseminate the data to the wider research and performing communities. The metadata we are recording could in the future be transformed into a different format, such as MARC, and assimilated into larger databases.

3.1 Dance Database Schema

The archive supports data types that are already available or those we aim to produce. This includes textual descriptions about dance types, video recordings and motion capture data of individual performances, metadata of dancers appearing in performances and the locations these dances are performed. The schema of the database used to structure the different information about Cypriot folk dances consists of 6 main tables (see Fig. 1 for a schematic summary):

[3] The Cypriot Folk Dance Archive is currently hosted at: `http://graphics.cs.ucy.ac.cy/dancedb`

- **Dances** - each entry of this table is a unique dance and accompanying metadata, which include the name of the dance, the type of dance, the region it originates from and a description.
- **Performers** - each entry describes a unique performer. Fields of the table include the name and date of birth of the performer, his/her gender and the date at which the dancer has first began dancing.
- **Locations** - each entry is the place that the data have been captured. Typically these locations have a name, address, a contact and the name of an administrator.
- **Videos** - each of the video data entries is a video recording of a dance performance. The video data has a timestamp to record the date the video was captured, the filename of the actual video and an arbitrary description.
- **Mocaps** - each entry is a description of the motion capture data of a unique dance performance. The motion capture data has a timestamp field to record the time it was captured, a filename pointing to the actual motion data and a description field to hold generic information.
- **Performances** - is the central table of the schema. Each entry is a unique performance of a dance and has a timestamp field and a description of the performance. The rest of its fields contain indices of entries in other tables which enables creating one-to-many relations for a single performance. A performance entry is a unique manifestation of a dance type and thus the dance index is stored in a performance's field to relate them. Each performance may be related to multiple performers, which is necessary for dances with groups of performers, thus the list of performer_id of the performers table is stored with each performance. A performance takes place at a single location, but the venue may be reused for multiple performances, therefore each performance records where it has taken place. Similarly, a list of video and a list of motion capture data indices are stored to relate a performance with the relevant data. Note however, that there may be more than one dataset for each type. For instance, when multiple cameras are used, a performance will have multiple video data files associated with it.

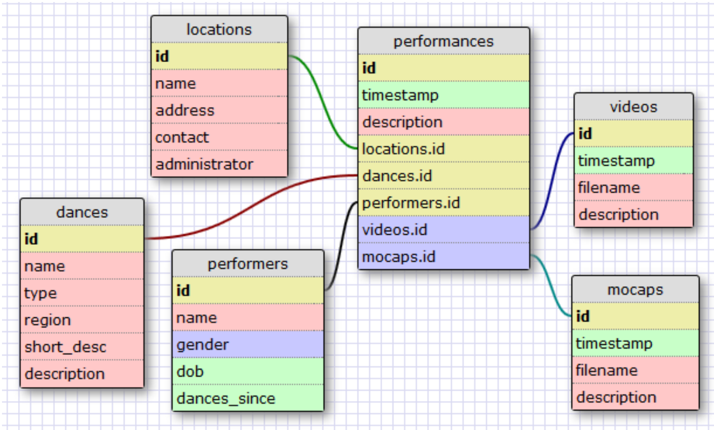


Fig. 1. The 6 main tables of the folk dance database schema. Connecting lines represent secondary key pairs that are stored in lookup tables used to relate individual performances to the entries of other tables.

3.2 Digitizing Folk Dances

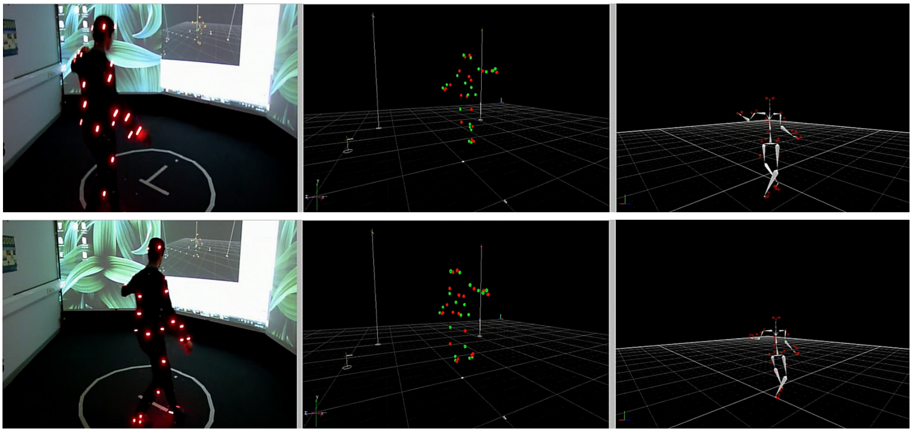
Optical motion capture is a technology used to turn the observations of a moving subject (taken from a number of cameras) into 3D position and orientation information about that subject; thus, it provides real-time acquisition of labeled 3D marker data. These data can be used for reconstruction of the human skeleton allowing accurate real-time feedback via tracking and modeling of human motion. Motion capture data are used for motion tracking and position sensing to several industries, including major film and game organizations.

The Computer Graphics and Virtual Reality Lab (VR Lab) of the Computer Science Department, University of Cyprus, has recently re-equipped with a new motion capture system (the new Phasespace[4] Impulse X2 motion capture system with active LEDs) and a 3-wall immersive virtual reality set-up. The Phasespace Impulse X2 system uses 8 cameras that are able to capture 3D motion using modulated LEDs. These cameras contain a pair of linear scanner arrays operating at high frequency each of which can capture the position of any number of bright spots of light as generated by the LEDs. The system offers a fast rate of capture (480Hz) and allows the individual markers to be identified by combining the information from several frames and hence identifying the marker from its unique modulation. The markers are placed at strategic points on the articulated body so that these points can be easily and accurately located by the cameras. The subject moves in a specified space that can be tracked by the cameras and the markers attached to its body are tracked over time and used to reconstruct the three-dimensional pose of the subject at each instant of time. Our system is able to capture 3D motion data over time of a single character, maintaining the correct human proportions and the naturalness of the action, while having a realistic motion.

The first step of digitization is the motion capture of a performing character. The dance performer wears a special outfit (mocap suit) that can be observed from the cameras (for one character 8-32 cameras are usually used) surrounding the site where the character moves. Every mocap suit is attached with 38 markers (active LEDs); having secured that at least 3 markers appear on each part of the body at each time (so we can have all three possible rotations), we can estimate the centers of rotations (joints), thus, extract the skeletal model of the character. The human skeleton model is divided into 6 different kinematic chains, meaning the head, spine, left hand, left leg, right hand and right leg. Having the positions of the character skeleton (or every joint) over time is equivalent of capturing its 3D motion in space. In order to give a more realistic form to our virtual character, the reconstructed skeleton has been incorporated to a digital grid (mesh) that describes the shape of the virtual character (in our examples, the virtual character is a man wearing the Cypriot traditional uniform).

As a first step of our project, we captured 3 solo men dances: first antikristos (πρώτος αντικριστός), second antikristos (δεύτερος αντικριστός) and zeimpekiko (ζεϊμπέκικο). Fig. 2(a) shows the dance performer wearing the mocap suit and performing zeimpekiko at the VR Lab of our department. Fig. 2(b) presents the markers positions over time as they are being captured by the Phasespace motion capture system, while Fig. 2(c) illustrates the skeleton of the character after the joints

[4] Phasespace Inc: Optical motion capture systems. `http://www.phasespace.com`



(a) (b) (c)

Fig. 2. (a) the dance performer wearing the mocap suit and performing a solo dance at the VRL laboratory, (b) the marker positions as seen by the motion capture system (view from the opposite site), and (c) the skeleton reconstruction (motion) of the character as captured by the mocap system

have been estimated. Please note that a different view angle was selected for every video-picture so that it is obvious to the reader that the data were recorded in 3 dimensions. The system described above offers mobility enabling motion capture sessions to be performed at dance schools and studios.

Our system is able to capture the 3D positions of just one person at a time, making it ideal for digitization of solo dances, such as zeimpekiko. However, a number of dances involve multiple performers (e.g. first antikristos is performed by a pair of dancers, a male and a female, one dancing opposite to the other). Capturing multiple performers is technically challenging. We attempt to tackle multiple-performer dances by using the appropriate number of performers required for the dance, but actively capturing motion data from one performer, the one wearing the motion capture suit. We note, that that there are instances where the group leader is performing differently than the rest of the group. In that case, our digital library will include the performance of both the group leader and the tail. In case of a pair dance, a male and a female version of the dance will be captured independently.

4 Teaching Cypriot Dances with a Video Game

Historically, folk dances have been preserved by the teachings of expert dancers to novices, in a teacher-to-student relationship. Later choreography notation systems, such as Labanotation, have been developed and used as the primary means of systematic archival of folk dances. However, these notation systems require special knowledge for comprehending them and furthermore it becomes for novices very complicated learning or performing the dances recorded with them. Instead of choreography notation systems and formal instruction, nowadays recorded instructional video of live performances is a popular way of learning to dance. A relatively new trend in dance teaching is the use of 3D virtual environments, such as games, enriched with avatars that train users in dancing. A widely popular example is the Dance Central XBox360 game by Harmonix Music, which uses Microsoft's Kinect for tracking the user's motion and offers a range of modern dances that users can choose from.

Similarly, in this project a game is being developed using the Unity3D engine and Microsoft's Kinect exclusively for teaching Cypriot folk dances, as a means of promoting and preserving the local folk dance heritage, especially through teaching younger generations. The game will initially be available as an installation at the Cultural Workshop Ayion Omoloyiton in Nicosia (Cyprus) aimed at the young children frequenting the dancing activities of the institution. Since traditional Cypriot dances require more individual rather than group practice the game could also be suitable for home use.

The game features the 3D avatar of a Cypriot dance teacher dressed with the traditional costume and supports a range of template motions performed by experienced local folk dancers of the Cultural Workshop Ayion Omoloyiton. The user selects the dance he would like to learn from the motion capture database, described earlier, which is attached to the virtual dancer. The virtual dancer demonstrates the motion to the user, see Fig. 3, and then the user is asked to perform alongside the virtual teacher. The motion of the user is captured in real-time via the Kinect and is attached to a second virtual avatar, so that the user has visual feedback of his movements. A motion matching algorithm is used to measure the similarity of the user's motion to the motion template. A feedback system provides hints and advice to the end-user as to his performance and parts of the dance that would require more practice and attention by the user.

Fig. 3. On the left hand side, a virtual male dancer wearing the traditional Cypriot costume that is controlled by the body movements of the player. On the right hand side the virtual teacher is demonstrating the dance the user should perform. On the top-right corner the inset image shows the depth values generated by the Kinect sensor.

At the core of this educational game is the ability to automatically compare the user's motion captured with the Kinect in real-time to an expert's template motion as this has been digitized and stored in the database. This poses a number of significant challenges for which solutions are actively researched in the area of Computer Animation:

(a) *Different Skeletal Structure* - professional motion capture systems, such as those used for recording the dance data of the digital archive, are very accurate and usually feature hierarchical human skeletons comprised of a large number of configurable joints. In contrast, due to the technology and algorithms involved, Microsoft's Kinect provides significantly less accurate data for a fixed 20-joint skeletal structure. Therefore, directly comparing the data is not appropriate and thus we seek solutions to normalizing the two human skeletal structures for comparison. This does not only enable Kinect to be used with the data of the digital folk dance database, but also provides for using different or new motion capture systems as these become available.

(b) *Different Body Proportions* - one of the main issues with motion capture data reuse is the variable body proportions between humans. An expert dancer performing the motion may have different proportions than the current game user, which has to be taken into account and mitigated, using motion retargeting algorithms.

(c) *Comparing Motions* - probably the most important, but also difficult, problem is designing an algorithm that enables comparing motions. Motion matching or comparing algorithms typically use discrete motion samples which represent body postures to compute an aggregate distance metric between the two postures. In literature, the majority of methods can be grouped into those that use (i) the distances between the positions of body joints, (ii) the angular difference between respective joint pairs, and (iii) using the velocity of respective joints, or a combination of these methods. We have adopted a method based on the Motion Graphs posture comparison algorithm. We calculate the distance between the skeleton of the player captured with a Kinect and the skeleton of the motion template data recorded using the motion capture system, described in Section 3.2. To compare a single posture we calculate the distance of the respective limbs using the positional data of the joints that do have counterparts in both skeletons, ignoring joints that are not available in one skeleton, i.e. in the less fine grained Kinect skeletal structure. Small windows of postures of the player, e.g. over 5 frames, are then searched using again a window of equal size into the template motion.

There is a wide range of algorithms that can be used to tackle the abovementioned issues and thus we are currently researching which could best be used.

5 Future Work

This project provides the foundation for creating a digital archive of Cypriot folk dances that goes beyond, text, photographs and video, by incorporating high quality motion capture data for the first time. Digitizing the Cypriot folk dances will pave the way for documenting the cultural heritage of the Cypriot dance tradition (documenting the Cypriot choreography), particularly for traditional dances that tend to be neglected or forgotten.

We have designed an initial database that can accommodate the most important data and metadata that are currently available for these dances, but in the future we plan to expand this schema to include other forms of documentation that do not currently exist. For example, for the majority of these folk dances, dance notation scores do not exist. It could be possible to use algorithms that convert Computer Animation into Labanotation [3] and store this data into the database to enable choreographers to both use them, as well as refine them.

In this project we have developed a complete, albeit prototype, system for digitizing, archiving and reusing folk dance movements. As mentioned in the previous section, there are many technical challenges, especially for remapping motion to arbitrary skeletal structures, as well as measuring the similarity between motions. One of the research goals of the project is to develop algorithms that are better suited for tackling these problems with regards to dancing.

A longer term goal is to use this method of digital preservation of folk dances for dance heritage in other countries. The ability to compare motions algorithmically could improve our understanding of the origin of dance moves and exchanges of cultural characteristics between ethnicities in the region.

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