UTILIZING ANIMATION AND MOTION SENSING TECHNOLOGIES FOR MACEDONIAN FOLK DANCES VISUALIZATION AND ANALYSIS

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ABSTRACT

This paper describes a framework of presentation and analysis of Macedonian folk dances using two different approaches: 3D animation software tools and motion sensing technology. The purpose of such a framework is to provide a way of detailed, accurate and quantifiable description of the Macedonian dances (and dances, in general) in order to provide recording, archiving and analysis, and by that, a substructure for educational applications. The analysis of the corelation of the dance moves with the music can provide additional support in the dance teaching/learning process.
The framework implements visual presentation elements of the moves (3D animation, video, images, annotations, graphs, etc.) what makes the perception of the dance objective, accurate and understandable. This is particularly important because most of the existing materials regarding Macedonian folk dances are printed or contain only unmanageable contents i.e. they contain only non-visual presentation elements of the dance moves (text, drawings, images, annotations etc.) and cannot be used in additional analysis and as framework resources.Keywords: Innovation, technology, research projects, etc.

Keywords: folk dance, music, Maya, 3D animation, visualization, Kinect, motion, analysis

I. INTRODUCTION

The analysis of the human body motion, due to its 3D nature, requires multidisciplinary research yielding different types of applications with different complexity level. Furthermore, this multidisciplinary approach relays on utilizing technologies which implement methods for processing different forms of human motion perception.
Regarding human gestures description and recording, especially in the case of dances, it has been a common practise to use annotation methods (for example, Labanotation). This method is largely used in the printed materials for the Macedonian dances [1, 2, 3]. However, in general, the number of persons familiar with Labanotation is insignificant, and there are even fewer persons that can use it correctly or on a regular basis [11]. Taking in consideration the opinions of interviewed Macedonian ethno choreologists and ethno musicians, it can be concluded that even in the case of a person experienced in Labanotation, the resulting notations for the same moves differ, even when they are simultaneously done by different persons. This means that Labanotation and other methods of printed dance descriptions could not be objective and accurate i.e. depends on the persons' experience and skills.
It is notable that a large number of this work is based on using the previous experiences and materials in some way. For example, there are workflows that implement Labanotation records readers or other kind of implementations of it [11]. Also, there are many examples of using a database of enormously big number of images or video sequences of human body poses (silhouettes) or moves. There are examples of optimizing such a robust systems of motion patterns recognition and presentation [6]. Still, the resources that systems require demanding and expensive, and the results are not adequate.
On the other hand, in the world, there is a significant input/work done in the field of utilizing automatic visualization and quantification of the human moves, and its implementation. One of the most common methods are based on motion sensing and motion capture technologies that implement computer vision systems with multiple cameras [5] and/or markers or magnetic sensors strapped on the dancers body [9]. There are examples of using other modes of sensing, pressure sensitive floor [7], for example. All these systems are relatively more accurate, and nowadays are generally more affordable.
Also, the music analysis and its characteristic features correlation/ comparison with the dance moves can provide good support in the framework implementation. This approach, when possible and properly implemented, plays a big role in the work. [4, 6].
It should be mentioned that for the purpose of automation and optimization of the workflows, there are different algorithms implemented in combination with the mentioned technologies. For example, there are algorithms for automatic segmentation of the dance motion in "primitive motions" (i.e. basic motions) [8, 10] and calculation of the music phrase time length [4], optimization of the process of gesture recognition by implementing the hidden Markov models [9, 10], etc.
All these methods and algorithms can provide a solid basis for different approaches in the studying and research of the dances characteristics. Therefore, for the purpose of presentation of dances in a way adequate for recording, digital archiving and especially for additional utilization in the individual (computer-based) learning methods, a combination of different techniques implemented in a compact system should be used [6]. In that manner, computer-based dance learning interactive systems can provide additional support in the dance learning even in the cases of conventional learning, and especially when there are no conditions for tutor guided learning.

II. FRAMEWORK OVERVIEW

A. Characteristics of the dances and the accompanied music used in the framework

In the design and realization phase of the framework, significant inputs from Macedonian folklore and ethnomusicology experts, ethnographists and ethno choreologists familiar with activities in the field of Macedonian dances recording were done. As a proposal, only some of the most popular Macedonian folklore dances, analysed in the existing materials and books are taken in consideration i.e. dances familiar to the general public and transferred over the generations - choreography and artistic dances are not included.

As the system implementation is in its starting phase, the accompanying music of each dance utilized in the work has a characteristic periodic phrase. Furthermore, the moves characteristic sequence is strongly correlated with the music rhythm (rhythmic dances). Also, in this phase of the work, there is only one dancer repeatedly performing the dance sequence.

A characteristic feature of the Macedonian folklore dances is performing by mainly using the legs. Taking this in consideration, the resulting animation is dedicated on the lower part of the body (legs and the hip). The upper part of the body (torso, arms and the head) is fixed regarding to the body i.e. hip space position.

B. Framework implementation

At the beginning, dances performed by Macedonian folklore dancers, were digitalized and recorded. This was done by using two video cameras (front and side views) and motion sensing device Kinect for Xbox 360. The video cameras used were non-professional cameras with 25 and 30fps (frames per second). The recording of the dancer gestures with the Kinect sensor was in order to create a database with the space coordinates of the lower body parts of the dancer. This data was imported in a file for additional processing.

In the next step, the input data from the dances digitalization process were processed in order to derive the parameters needed for the generating of the virtual character animation and for the dance characteristics analysis. Namely, the video sequences were segmented and labelled using annotation software Anvil [12] and Maya motion tracking tools [13]. This was done by marking the time moments of changes in the moves direction of the objects, music analysis regarding the rhythm beats, and analysis of the input data from the Kinect sensor. The data file generated from the Kinect sensor contains the 3D space position parameters of the dancers' body parts. This was needed for accurate determination of the time duration of each characteristic dance moves segment which is then compared with the characteristic music phrase.

In the end, from the marked timeline events and the 3D character coordinates parameters from the Kinect input, the virtual character animation import file was derived. This file contained the animation keyframe parameters. It was imported in Maya 3D animation software by using Maya API C++ software plug-in (created by using Visual Studio C#)

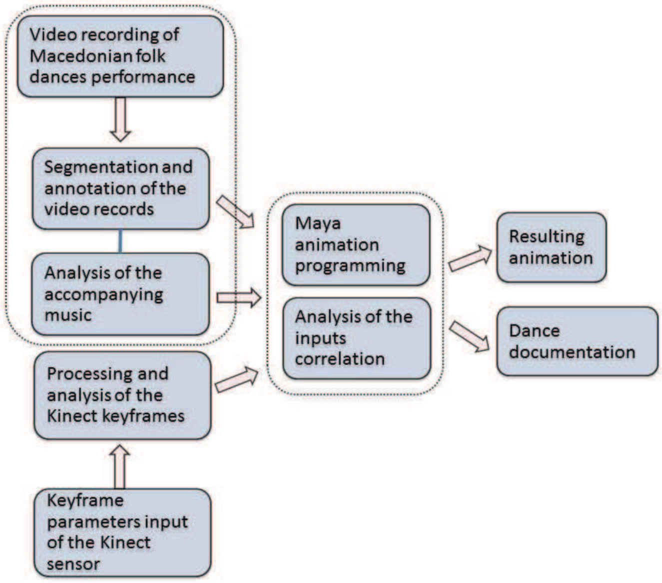


Figure 1. Workflow description diagram

Finally, comparative analysis of the resulting animation and data was performed by comparing the virtual character body parts with the dancer video sequence's picture frames , projected on the two camera views (Figure 2). Furthermore, the parameters in Maya are observed.

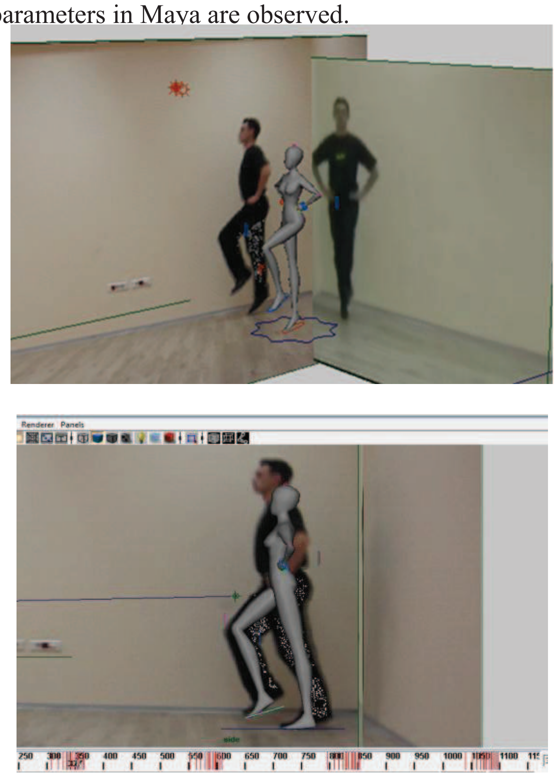
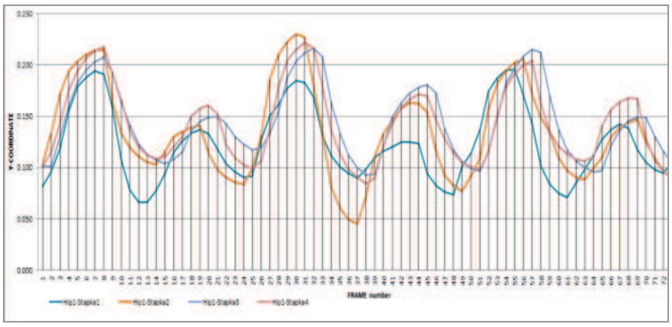


Figure 2. Preview of the Maya scene with the video record projected on the cameras planes and the virtual character animated in Maya

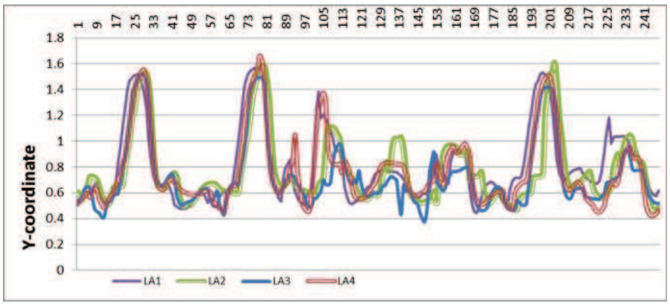
III. Results

The presented framework implemets the Macedonian folk dance “Pajdusko” analysis. The video segmentation of the characteristic moves phrase for this dance has resulted with 110 segments. Thus, annotation is done ten times more frequently compared to the Labanotation segments (total of 11 for the Particular dance, “Pajdusko”). Every segment represents single motion primitive and is described with multiple animation keyframes.

Figure 3 presents a graphic of the changes of the Kinect 3D space coordinates for the dancers hip and left ankle in four successive time periods. The time duration of the dance characteristic sequence is 8sec209ms.



a.



b.

Figure 3. Time changes of the Y-coordinates (height) values for the hip (a) and the left ankle (b) of the dancers’ body in four successive dance characteristic sequences shifted (overlap) in one dance phrase time period

It is notable that the values of the biggest amplitudes of the four performance iterations are similar i.e. the difference in the height of the lifting of the hip and the foot is insignificant in comparison with the short moves. Utilizing the statistical computing software package R [14], the minimum auto-distance/similarity between the time series of the left ankle Y-coordinate is 5.223%. The appropriate value for the hip Y-coordinate is 3.167%

IV. Concluding Remarks

The animation is represented by a significantly larger number of segments i.e. the video annotation and the keyframing is done multiple times more frequently compared to the Labanotation segments. The animation of the virtual character is done with 32fps. Hence, the moves coordinates’ precisionsy is on a high level. Therefore, the resulting animation gives a smooth authentic visual presentation and provides an objective perception of the dance performance style and dynamics.

The presented framework is most notably suitable for recording and digital archiving, presentation and analysis of dances and human gestures. This is achivied with combination of video, audio, text, images, annotations, graphs and diagrams, numeric parameters etc. Furthermore, it can be used for more comprehensive and detailed analysis of the dances regarding the supporting music and dance moves, different criteria movement parameter quantification (dynamics and energy), dances comparison (gender and origin factor differences), etc.

Future work will focus on several aspects: framework automation and implementation as online application, basis for development in a distributed system for long distance learning of the folklore dances and music. Additional aspects can be explored in terms of upgrades of the implemented costumes, multiple dancers physical interactions and as a solution for dances without accompanied music or with week correlation with the music, etc. The interactive aspects of the system can be further enhanced with development of framework that will utilize the other features provided by the natural user interface technologies, i.e Kinect sensor, and automatic implementation of the appropriate mathematical functions and statistical analysis packages.

In the end, the proposed framework is especially applicable as a basis for educative applications by providing teaching and individual learning of dances. This is accomplished by providing multimedia tutorials and real time human-computer interaction technologies, thus making the dances more accessible and understandable for the general public. Additionally, the framework is seen as useful utility for folklore professionals in their work, and for the educators and practicions in the areas that invoke and implement human moves analysis and performances.

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