Dancing Into the Digital Age: Experimenting the Digitization of the Pauliteiros Folk Dances

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***Abstract* — Digitizing intangible cultural heritage is a crucial step in preserving and protecting traditions, customs, and knowledge that have been passed down from generation to generation. By creating a comprehensive record of intangible cultural practices, digitization allows for greater access, research, and education, promoting cultural diversity and understanding. This paper discusses approaches to the digitization of intangible cultural heritage, which allow the dissemination and preservation of knowledge applicable to folk dances, particularly in the context of ethnographic museums. Possible applications with this motion data will also be explored, such as Virtual Reality, Augmented Reality or video games. This paper finally discusses and proposes a framework for digitization of folk dances based on the practical case of the "Dança dos Paulitos" or "Dança dos Pauliteiros" [1], a Portuguese festive dance ritual tradition from Miranda do Douro in northeastern Portugal.**

Keywords - Intangible Heritage; Digitization; Framework; Mocap.

I. INTRODUCTION

Emerging technologies have been used successfully in recent years in heritage preservation. Through these, it is possible to recreate places, artifacts, rituals, crafts or any other type of cultural heritage to be readily available to the public in various roles: as documentary, touristic, and educational [2].

In a new era, where there is a great deal of attention on virtual 3D environments such as the Metaverse, it is important to explore these platforms for the preservation and promotion of intangible cultural heritage, allowing for greater access and wider dissemination of these practices. The digital recording of dances opens up a set of new possibilities for the use and dissemination of this type of heritage that traditional methods of safeguarding cultural heritage did not allow, promoting, for instance, a greater culture of presence in museum spaces. For example, the recent interest of museums and art galleries in using new technologies and interactive applications, aiming to create more engaging experiences for their visitors [3]–[5], is confronted with the inexistence of the digital record of heritage in modern and adequate formats. Teaching is another application area, in which the digital recording of dances allows the creation of immersive solutions and contents that improve the learning experience and that would not be possible without this type of recording. Some examples are presented in [6]–[10] which present solutions that make use of motion capture data to teach dances, rituals, martial arts, and others.

In this text, we will focus on developing a theoretical framework for digitizing folk dances, using as a test case a traditional dance group. This performance aesthetic data will be then applied to virtual dancers, dressed as "Pauliteiros", for the production of 3D animations or video games, or to be used for the production of the most diverse digital content.

To do so, a brief description of how digitization can help preserve cultural heritage, and the role of performance motion data in this process. In section III, the theoretical framework will be presented, and how it can help in the digitalization of dances will be explained. Then the technical and technological specificities of the practical case of digitization of "*Dança do Paulitos*" or "*Dança dos Pauliteiros*" are discussed. In section IV, the potential of digital capture and recording is explored, and how it can be used in the various applications that support digital motion capture for animation. Finally conclusions are addressed.

II. RELATED WORK

A. Heritage Digitization

Nowadays, we can look at the challenge of cultural heritage digitization, specifically the digitization of intangible cultural heritage, to some extent, in the same way, museums where first challenged to fully grasp communities culture including not only their artifacts and material objects but their intangible aspects, as discussed by Stanner [11] regarding the "display" of australian aboriginal culture in museums.

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Arguing, at the time, the insufficiency of object display to communicate culture and advocating the need for communities participation in the curation of exhibitions about their cultural practices, Stanners' questions, are, still today, strongly debated in museology as we can read in works such as Cristina Kreps' *Indigenous curation, museums, and intangible cultural heritage* [12]. The use of digital media, has been pointed out as a way to solve some of these problems and many experiences and studies are, today exploring technologies as means for a more integrative way of capturing and recording intangible cultural heritage - either through video, virtual reality or the metaverse, thus recreating, to the most extent possible the complexity of intangible cultural heritage practices. For instance, one of the latest trends has been gamification, which potential for ICH preservation and dissemination, is interestingly explored by Majewski [13], who describes the use of video games for ICH as a convincing way of building a virtual cultural world. Thus throughout the years, and in spite of many challenges [14], [15] the use of technologies still poses, in the context of museums (cost, maintenance, staff training, etc.) it is increasingly being used and growingly seen as a fundamental tool for the creation of more intuitive and interactive exhibition spaces. Likewise, the variety of technologies used has also increased and adjusted to the specificities of different kinds of heritage as shown by the collection of works displayed in the recently published *Visual Computing for Cultural Heritage* (2020).

Therefore, and in what respects to the recording of movement centered intangible cultural practices, such as traditional folk dances or martial arts and other types of performances, there are several works that recognize the importance of its preservation through motion capture systems. In [10], the authors present a work to preserve and promote a martial art through a game capable of recognizing movements using a motion capture system and the Nintendo Wii. The Hong Kong Martial Arts Living Archive (HKMALA) is a digital strategy of archiving and annotating Hong Kong's diverse and rich kung fu styles and traditions, using state-of-the-art data capture tools, to promulgate rich cultural traditions [16]. In [8] the authors present a work of visualizing the three-dimensional Slovak Folk Dances and comparing their educational potential in relation to video recordings. Motion is also an essential feature in recreating realistic virtual environments. This happens in [17], where a crowd simulation for virtual heritage is presented, creating and 3D reconstruction of ancient buildings and characters and motions were collected by motion capture with the aim of preserving and disseminating this heritage. In [18], a project to preserve and create a publicly accessible digital archive of the Cypriot folk dance heritage is presented. Another goal was to disseminate this heritage among the younger community. This was accomplished by developing a 3D video game for children to teach folk dances.

Another area of use of the mocap system is in the area of dance classification, through the use of movement recognition systems [14][15]. This in turn can help in the process of learning folk dances [9].

B. The Pauliteiros Dances

The traditional Pauliteiros dances are ceremonial dances performed in the villages of Constantim, Palaçoulo and S. Martinho (municipality of Miranda do Douro) in honor of S. João Evangelista (Constantim) and Our Lady of the Rosary (Palaçoulo and S. Martinho). They are therefore an essential part of traditional ritual festivities which occur in different moments of the year according to the religion dedicated to the different saints the festivities honor (in Constantim Feast of S. João Evangelista (in São Martinho and Palaçoulo, the festivity honors Our Lady of Rosário and is celebrated at the end of August and mid September, in Constantim it is dedicated to Saint John Evangelista and it takes place the 28th of December).

The dancing group called Pauliteiros, composed by young men, take part in the festivities in different moments throughout, performing dances inside the houses of the villagers, out in the streets of the villages and in some religious moments as well inside the church [21]. They are distinguished by the traditional costumes that they wear and specifically by using sticks during the dances as part of the movement and rhythm of their performances. Usually accompanied by a small group of musicians who play bass drums and bagpipes, there is also a variety of songs to which they dance which are mainly sang in mirandês, the second main language in Portugal, only spoken in the northeast municipality of Miranda do Douro.

For our case study of digitization of the Pauliteiros Dances, we worked with the group of Palaçoulo village.

C. Motion Capture techniques

Motion Capture (MoCap), is a process of digitizing motion, in which an analog source, such as a human gait, is captured and transferred to a digital model, such as a character or an avatar [22]. The process usually consists of placing sensors on one or more people, such as actors or dancers. These markers have their movements tracked by motion capture devices, such as cameras. This data is then stored on a computer, to then be applied to digital models such as characters in games or movies. In general, body movements are captured separately from facial movements, due to the characteristics and subtleties of the latter.

Currently, motion capture devices can be classified as active or passive, synchronous or asynchronous, with markers or without markers and/or according to the physical principles employed [23]. According to the physical principle used, they can be divided into three main methods: mechanical, magnetic and optical. The mechanical system can be inertial, acoustic or based on prostheses. The optics are supported by a set of cameras that capture the scene. Each camera sees the scene in two dimensions and, after triangulation between the cameras, the depth of movement is recovered [24]. In magnetic capture, transmitters emit magnetic fields and receivers measure their orientation relative to a field whose strength and direction are known [25].

The capture of this data is represented by a Rig (Figure 1). This structure is similar to a human skeleton, in which the data set is presented through the visual representation of bones and

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joints. These elements are connected by constraints and controllers to simulate a movement hierarchy. Motion data is applied to this skeleton and the virtual model is immediately animated with the same movements made by the dancer. This can be previewed in real-time using real-time rendering software or post-produced using offline rendering software. Once this skeleton is functional, it is then linked to any 3D model with a process called parenting, so it can be rendered and we can see the result of the animation.

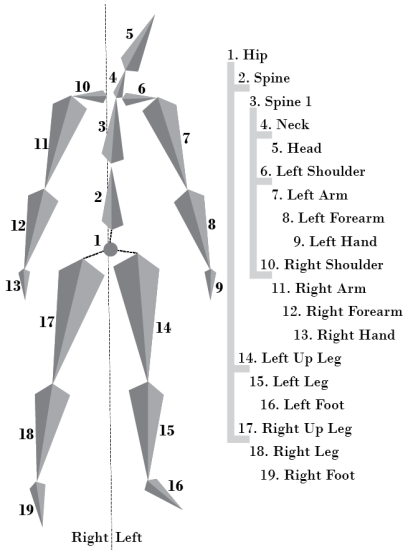

Figure 1. Biped Rig Hierarchy

III. Motion Capture Session

A. Motion Lab Description

To capture the movements of the dancers, we opted for the optical system, as it is more precise and allows a higher sampling rate and a larger capture area. We used the *Natural Point Optitrack* system from Natural Point (NaturalPoint, 2023), which allowed the capture of three dancers simultaneously in a volume of 7X7X2.5 meters. The laboratory has 16 High speed Primex 13 cameras of 1.3 megapixels, 240 FPS native frame rate, and 1000 FPS max frame rate. This system is capable of capturing movements with 3D precision of 0.20 millimeters and movement speeds of over 200 km/h, fundamental aspects due to the speed of some of the fast movements that occur in these dances.

The dancers in the capture suit start the movements from the T pose, in which they position themselves with the front of the body in the positive direction of the z and the arms open, so that the points are mapped hierarchically, on an object like the human skeleton, with the top of the hierarchy at the hips. The displacements of each marker are mapped over time and the system allows the output of data in files with appropriate digital formats, such as FBX or BHV, for use in 3D modeling and animation software.

B. Motion capture framework

To capture the movement of the dancers, an infrared camera system is used. The dancers wear black clothing, with markers on the body joints that reflect the infrared light. The dancers' performances can be captured simultaneously and digitally recorded in one of the standard formats. These records can then be made available in a file repository on the Internet, and can be shared and played back in various three-dimensional animation software, generating videos of the performances with the framing that the user desires.

The main goal of the digitization process is not only to result in a digital data set, but also to capture as authentic as possible a narrative composed of several styles: aesthetic, audiophile, kinetic and artistic. For this we defined a High level folk dance digitization framework (figure 2), which allows the digitization of this narrative, through four fundamental processes that are performed during the performance: video recording, photographic recording, audio recording and motion capture.

Figure 2. High level folk dances digitation framework.

In order to successfully perform the digitization, it is essential to record the performance including the various components simultaneously (video, photographic, audio and motion). However, audiophile recordings in specific audio labs are recommended for the purpose of obtaining better audio quality than in a motion capture lab.

Video, audio, and photographic records are valuable in themselves, since they can contribute to capturing part of the performance's digital record, but can also be used in the future, as part of post-production. For example, the photographic record may allow us to observe details in the process of creating 3D models, such as texturing. In order to synchronize the dances captured by the mocap system, audio and video recordings can be used. Figure 3, shows the workflow performed in the motion capture process of the dances.

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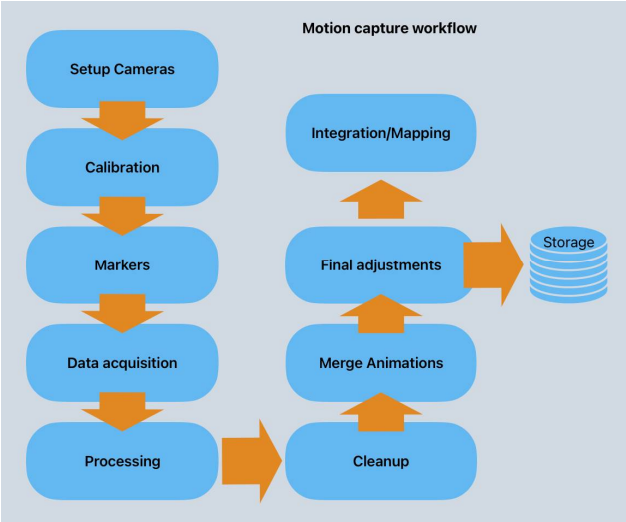

Figure 3. Motion capture workflow.

C. *Mocap session acquisition*

Our Mocap system is capable of capturing the 3D positions of only two actors simultaneously. The Pauliteiros group of dancers is made up of eight Pauliteiros (men or women) arranged in two parallel rows. The dancers are divided into the positions "*guias*" ("*guides*") and "*peões*" ("*pedestrian*") and distinguished in space by attributes like front, back, inside, outside, left and right [1]. As a rule, they can never leave their respective guides. The two guides at each end and their pedestrians make the "*quatrada*". Several dances of the Pauliteiros usually involve several performers (for example, the "dança dos lhaços" is made up of the 8 dancers). Figure 4, shows the rehearsal of the dance, before the capture session, the Pauliteiros, whenever possible, like to wear their costume in their performances.

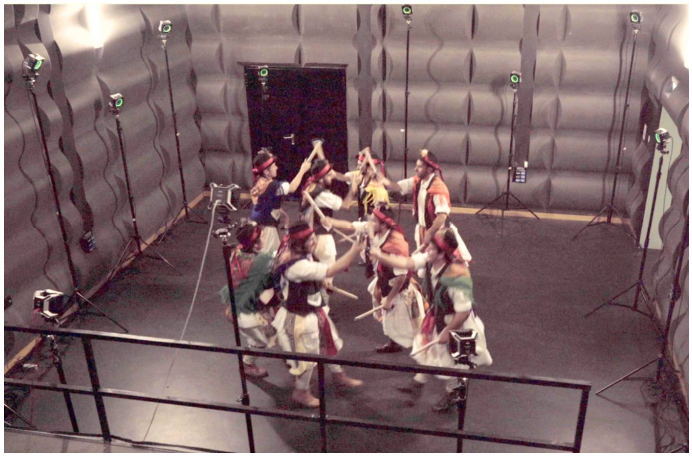

Figure 4. Pauliteiros performing "*Dança dos lhaços*".

Capturing multiple dancers is technically challenging due to the technical limitations of the mocap system, which only allows capturing the motion of two dancers simultaneously. For dances with more than two performers, we obviously used the appropriate number of performers needed for the dance, but actively captured the motion data of only two simultaneous performers. Those who wore the motion capture costume. At the end of each dance, the dancers wearing the mocap suits would alternate positions within the group, so that all performers wearing the suits would dance in all possible positions. In the end, we would have several motion captures of the same dance with the performers executing their performance in different positions. This problem can be minimized with video recording for references in post-production, and audio clapping for syncing.

For example, the "*dança dos lhaços*" is composed of 8 dancers and during the dance, they sometimes perform non-symmetrical group movements. In this case, it was necessary to perform the dance 4 times, recording the movements of two dancers in each performance. Figure 5 shows one of these motion capture sessions with two dancers wearing the costume, on the screen you can see the capture in a 3D space in real-time. Subsequently, the mocap data from each of the sessions go through a refinement process to correct any movement deviations that may have occurred. One of the parts of the dancers' movements that required the most attention was the hands because due to the high number of markers on the hands and the proximity between them, errors sometimes occurred in the capture of movements. However, these are easily identifiable and corrected in animation software, because during the performance the dancers hold the sticks, with the fingers of the hand being in the same position relative to the palm.

To capture the movement of the sticks, several solutions were tried, all of them unsuccessful. First markers were attached to the stick and it was selected as being a rigid body, however, due to the violence with which the dancers hit the sticks during the performance, the marked ones ended up bouncing. Reflective tape and spray with reflective paint was then tried on the sticks, but the system did not handle these alternative markers well. In the end, it was decided not to do the movement acquisition of the sticks. It was observed that the sticks stayed in the same position and angle relative to the dancer's hand. So the stick can be added in the future as a rigid body in a parenting relationship to the dancer's hand in the animation software. When an object has a parent, it will perform all its transform changes with respect to another object instead of the 3D world. A parent object causes all child objects to move and rotate the same way the parent object does, although moving child objects does not have any effect on the parent [26].

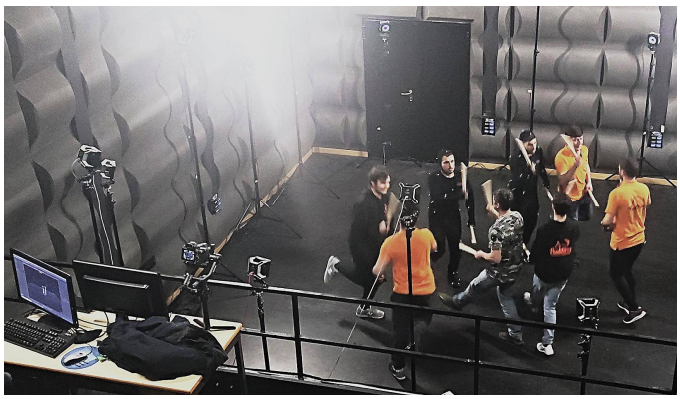

Figure 5. Motion capture session.

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Once the data is captured, it is saved in FBX format. This is a proprietary format created by Autodesk in 2006, it is found in the vast majority of 3D animation software. Although the FBX format has a wide range of data compression, these files are still quite large, because for each frame the position of each bone receives 3 coordinates (X, Y, Z) in each transformation (position, rotation and scale), figure 6.

Figure 6. Data animation of the one dancer in FBX.

In order to be worked on common computers, in our case an Intel i5 11600k with an nVidia RTX 3060 GPU with 12GB of VRAM, these files must be optimized, which leads to loss of detail in the captures, since the transformations are optimized through simplification of the coordinates. In this specific case, in which the eight dancers (figure 7) are captured two by two, it is necessary to merge and synchronize the four motion capture files, using Blender's Non-Linear Animation Editor, NLA. In addition to being synchronized with each other, the movements must be synchronized with the animation audio. This is recorded along with the reference video, on which the animator is guided throughout the process.

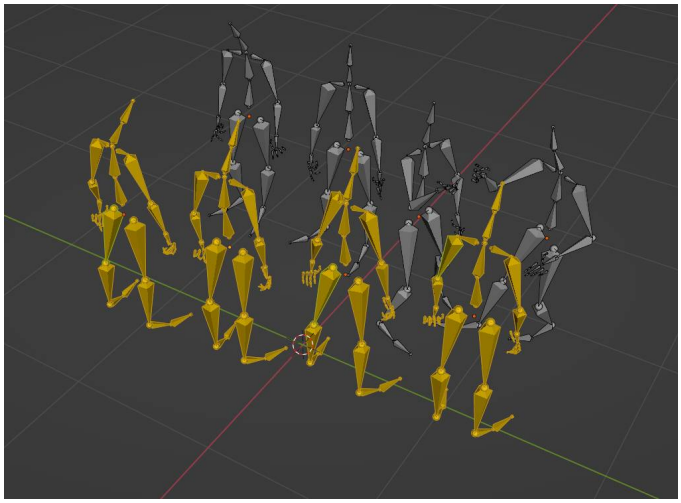

Figure 7. Resulting animation file of the 8 dancers.

IV. USER CASES SCENARIOS

The capture of the various types of media and motion capture made from this type of experience allow not only safeguarding cultural heritage, but also a wide range of opportunities that have been developed for different purposes such as culture and tradition transmission, cataloging, education, and teaching.

With the movement data, virtual dancers, wearing typical Pauliteiros costumes, can be created for the production of animations. These animations can be reproduced in a variety of video formats or in virtual reality, making them easily accessible to animation and video game studios.

Intangible cultural heritage can play a significant role in the Metaverse by providing a rich source of cultural content and experiences. Cultural practices such as music, dance, and storytelling can be incorporated into the virtual world, offering opportunities for people to engage with and learn from different cultures.

Virtual guides have been introduced for physical museums as a novel way for capturing the attention of different user groups such as children [27], and for virtual museum contexts to engage the visitors through storytelling [28] . For example by analysis and evaluation of mime movements, in this case dances, which can be used for teaching dance purposes or even as a type of entertainment experience, similar to the Just Dance game, for families during a cultural visit.

With videos and a motion capture system, it is possible to reproduce their movements, capture them and display them on a screen, in real time, and compare them with the movements of the dancers in the dance group. With this motion data, we can frame the image to reveal details of the dancers' movements, and correct and enhance your own movements.

V. CONCLUSIONS

This paper showed how we approached the design of a framework for digitalization of dance ritual traditions. Starting from a particular case study, a set of recommendations and a workflow process were specified that help the record of intangible cultural practices. Some case scenarios on how to use audio, video, photography and movement data were also presented.

This is a pioneering study in Portugal, which aims not only to record these ancestral practices, but mainly to make them accessible and encourage their use by the various stakeholders in the creative, cultural and tourist industries. Who otherwise would not have access, since these motion cap systems have very high costs and typing this type of performance is time-consuming and expensive.

Additionally, this work intends to continue the development of the contextualization of the implementation of digitalization strategies of museum collections in Portugal and their struggles both to implement these strategies, as well as to invest in the creation of digital tool applications for public engagement.

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