A Theoretical Framework for Creating Folk Dance Motion Templates using Motion Capture

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***Abstract*—Folk dance (FD) is a type of traditional dance that has been handed down through a culture or group from generation to generation. It is crucial to preserve and safeguard this type of cultural legacy since it can reflect the history and identity of particular nations. However, due to ineffective preservation and conservation techniques, the survival of FDs is being negatively impacted more and more. Its extinction may be caused by ignorance about and disregard for preservation and conservation efforts. The most efficient method for digitizing intangible cultural property, including FDs, is motion capture (MoCap). MoCap enables the conversion of real-time movement into digital performance to produce motion templates. This paper aims to provide suggestions and guidelines in conducting research to generate motion templates of FDs. Several key approaches are presented and discussed in detail, including acquaintance meetings, procedures and approval, interviews and experiments, and the framework. The proposed framework includes models for MoCap, skeleton generation, skeleton refinement, and evaluation. By implementing the proposed framework, the motion templates for FDs can be created. The generated motion templates will preserve and conserve FDs and guarantee their originality and authenticity.**

Keywords—Motion capture; folk dance; motion template

I. Introduction

Since cultural heritage reflects the history and identity of certain countries, it is important to preserve and conserve it. Cultural heritage refers to the inherited beliefs, values, customs, practices, and artifacts that define a group or society [1]. It includes both tangible and intangible elements that have been passed down from generation to generation. The National Heritage Act of 2016 defines intangible cultural heritage as a human action or movement that can be observed, felt, tasted, smelled, or heard when performed or present, but cannot be appreciated when lost or disappeared [2]. This includes performing arts, customs and culture, oral traditions, fine arts or crafts, knowledge and practice, and living heritage.

Folk dance (FD) is considered a ritual among people that is a characteristic of the common inhabitants of a country or region that is passed down from generation to generation [3]. By performing such rituals for many years, people have gathered and performed such rituals to develop bonds with each other and connect with the space where they spend or spent their daily lives [2]. Dance is a performing art and consists of various movement sequences [4]. It can have different messages depending on the context due to their close relation to the culture and heritage of a place or nation [5]. Moreover, each dance creates a meaning, a story with the help of music, costumes, and dance movements [6]. In Malaysia, FD has been registered and categorized as performing arts under Intangible Cultural Heritage. Performing arts is a form of stage performance that is performed directly or immediately for the audience or spectators and involves four basic elements, namely time, space, and the relationship between performer and audience [2]. Examples of the most popular FDs in Malaysia are Tarian Gamelan, Tarian Piring, Tarian Zapin, Tarian Mak Yong, Tarian Sumazau, Tarian Ngajat, Tarian Kipas, Tarian Kathak, Tarian Kuda Kepang and others [7,8].

However, this kind of heritage can easily die out over time if it is not a tangible heritage. This is because the younger generation is not interested in passing on the cultural heritage and because of the changes in traditions (the transition to modernity) [2]. These reasons have significant impacts in the form of loss, neglect, extinction, and destruction. In addition, current methods for teaching, learning, and assessing FDs focus on human demonstration, text documentation, and video [9]. Human instructors such as teachers and coaches are usually involved to give commands or demonstrations about the dance movement [10]. Santos [11] described three limitations when a person attempts to provide feedback: The person cannot maintain the same level of attention and concentration for an extended period of time; they are unable to observe all the important physiological and biomechanical variables that characterise the movement, either at the same time or with high precision; and they are unlikely to provide extended simultaneous feedback. The use of text documents is suitable for presenting information about dance and its cultural significance, but it cannot present movements and different dance styles accurately [10]. When using videos, the movements of dances can be easily presented, but it is static (2D) and difficult to present additional information about each dance [10]. The existing framework from previous research is not sufficient to create the motion templates of FDs from scratch. Therefore, there must be a stable mechanism to preserve and maintain this kind of valuable intangible cultural heritage.

Digitization and visualization of FDs is an increasingly active research area in computer science. With the advent of rapidly advancing technologies, new ways of learning folk dances are being explored that enable the digitization and visualization of various FDs for learning purposes using different tools [10]. One of the methods for such purposes is

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motion capture. Motion capture (MoCap) is one of the most effective methods for digitizing intangible cultural heritage, including FDs [6]. This is because MoCap enables the translation of live motion into a digital performance [12,13,14]. Mocap can also be used to recreate dances in three dimensions and display them in a 3D environment [15]. In other words, MoCap can be used to create motion templates. The use of motion templates in FDs has gained popularity in recent years due to the numerous advantages they offer. Motion templates are predefined movements or poses that are captured using motion capture technology and can serve as a reference for dancers to learn and perform choreography [16].

In this paper, a theoretical framework for creating motion templates of FDs using MoCap is proposed and presented. Different techniques and approaches for data acquisition and analysis are discussed in detail. In addition, the importance and processes of digitizing FDs with MoCap are highlighted to preserve and maintain folk dances by creating movement templates. This paper covers materials and methods in Section II, data collection and analysis in Section III, expected results and discussion in Section IV, and the last Section touches on the conclusion.

II. Materials and Methods

To ensure the success of preserving and conserving FDs through digitization, various formal and informal research approaches can be used. These approaches include conducting acquaintance meetings, procedures and approval, interviews, and conducting experiments. The results of these approaches are important in obtaining the needed information and proposing the framework shown in Fig. 1. The framework includes the acquaintance meetings, procedures and approvals, interviews, experiments, and workflows.

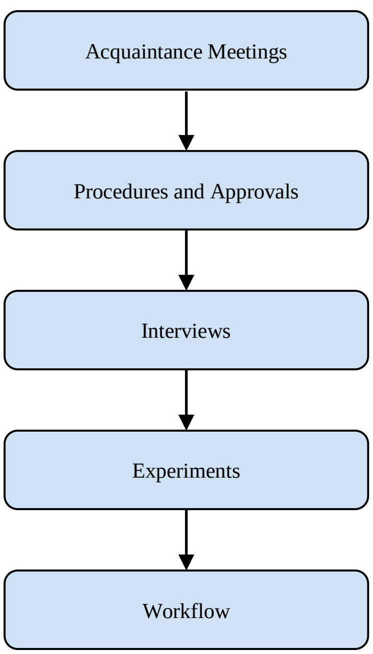

Fig. 1. Proposed framework for creating motion templates of FDs using MoCap.

A. Acquaintance Meeting

The main purpose of acquaintance meetings is to gather information about the FD present in certain areas. Therefore, meetings with FD experts from the State Tourism Department and the Centre for Arts and Heritage at the local Institute of Higher Learning (IHL) are crucial to gather the information. The results of the acquaintance meetings can take the form of the following:

- Documentation of local FDs such as forms, articles, journals, policies, and guidelines.
- Identification of experts/founders of the local FDs
- Clarification of history and background of local FDs
- Explaining the movement styles and types of FDs

The knowledge gained from the acquaintance meetings can be used for the next steps; procedures and approval.

B. Procedures and Approval

To further investigate the local FDs, the procedures and approval related to laws and their procedures can be applied and implemented. These are listed below:

1) Letter of intent for conducting the research at the potential sites/locations: The potential sites/locations usually result from the previous acquaintance meetings. This letter is important to obtain the consent and cooperation of the potential sites for the study of the corresponding FDs. The content of this letter must address the need and importance of researching the local FDs, in addition to explaining the research team and the use of current technology to digitise the FDs. The need for teachers, experts or trainers to participate should also be mentioned in this letter.

2) Invitation letter for conducting the fieldwork: Once the consent and cooperation of the potential sites have been obtained, this letter should indicate the need for recording the movements of the masters, teachers, experts or trainers in the target sites. This fieldwork typically involves recording the movements of teachers or trainers using specific MoCap devices. The recorded movement data can be used as motion templates. The content of the letter should include an explanation of the type of MoCap devices used in the fieldwork and the results obtained when using the recorded movement data to create the movement templates.

3) Request for Verification of Motion Templates: The purpose of this letter is to request expert assistance in verifying the motion templates developed using the captured motion data. This step is important to ensure the authenticity of the local FDs under investigation. The letter must include the need for multiple experts among the masters, teachers, or instructors to be present at a specific date, time, and location.

4) Application for copyright: Copyright may be requested for any movement template created by FDs. The rights that creators have over their literary and artistic creations are critical to describing the copyrights in the created movement templates. The letter can be forwarded to potential parties that can assist in funding and managing the publication of copyrights, such as the Intellectual Properties Corporation, the Division of Research and Development in certain IHLs.

These procedures and approvals step must occur in order for the research to be conducted effectively, especially when laws and confidential issues are involved.

C. Interviews

Interviewing is one of the most important methods to obtain and collect information about the FD under study and to verify the validity of the information. The interview can be conducted in a variety of formats including structured, semi-structured, and unstructured interviews [17] to meet the experts on FDs such as masters, teachers, trainers, etc. The frequency of interviews depends on whether the information collected is satisfactory and sufficient.

The results of the interviews are usually overviews of the type of FDs under study such as background, history, founders, and types of movements. In addition, the experts can be educated about the purpose of the study and the experiments to be conducted.

D. Experiments

The experiments are proposed to implement the methods planned in the research such as the proposed workflow and the collection of data from MoCap. The experiments usually involve the FDs experts and trainees in two different phases (development and evaluation), especially in collecting and recording their movements with MoCap devices. The development phase focuses on creating motion templates for FDs to use as benchmarks and reference sources. FD experts among teachers and trainers are involved in this phase. Later, the motion templates produced will be used as benchmarks in the dance evaluation phase by comparing the dancers' physical movements with the recorded movements in the motion template.

Therefore, explaining the experimental procedure is crucial to achieve the desired results. This includes the frequency of repetitions of the movements to be performed during recording with MoCap, the position and distance between the dancers and the MoCap device, the types of FDs to be implemented, and the types of actions to start and stop the movements.

E. Proposed Workflow

To generate the motion templates of FDs, the workflow in Fig. 2 is proposed. The workflow includes MoCap, skeleton generation, refined skeleton, and evaluation models. This workflow is used in the development phase.

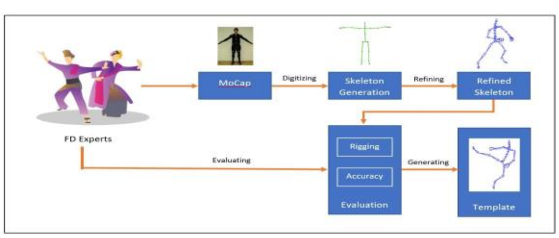

Fig. 2. Proposed workflow for creating motion templates of FDs using MoCap.

1) MoCap: The MoCap model is used to capture motion data using specific MoCap techniques. MoCap techniques can be divided into marker-based and markerless MoCap. Both techniques have their own advantage in terms of performance, accuracy and cost. Examples of marker-based MoCap devices Optical Motion Capture System Qualisys, Vicon, Peak Performance Motion Capture System, Optoelectronic Motion Analyser, Eagle-Hawk System, and MAC3D Motion Capture System, while markerless MoCap devices are Kinect, PrimeSense Sensor, Sony PlayStation Eye, and Intel's Creative Camera [18].

The selection and use of these sensor devices usually depends on the provision of research funding and the complexity of the captured motion [19]. The marker-based MoCap techniques can guarantee high accuracy in capturing and tracking the human movements. However, attaching markers to a performer's body can restrict the performer's movements, which may affect the quality of the performance [20]. Moreover, marker-based MoCap techniques are usually developed in specialised and static studios. The cost of developing such studios is high. In contrast, the markerless MoCap techniques offer more freedom in movements and performance, as well as affordable prices, since no markers are attached to the performer's body, and no specialised studios are needed.

2) Skeleton generation: The skeleton generation model is used to project the skeleton for body movements. The data obtained from the motion recording is considered accurate. The skeleton is a set of systematically linked joints. The skeleton data is converted to specific file formats such as SKL, FBX, BVH, and CSV so that it can be used to enhance the data.

The skeleton file format (SKL) contains motion capture information, i.e., the spatial locations of points on the human body called joints. The SKL file format can be used and supported in Kinect Studio, Gesture Description Language Studio (GDL), and OpenNI [21,22]. In addition, the SKL file format can be found in the documentation for the 3D modeling software MilkShape 3D. According to the documentation, SKL files are "skeleton files that contain the bone hierarchy of the model and the positions and orientations of the bones in each frame of the animation" [23]. This file format is also used to capture motion data from human subjects during various exercises [24].

The FBX file format is created using the Autodesk FBX program. This file format can be created and modified in a variety of modeling programs such as Maya, 3ds Max, and Blender. FBX files can contain a variety of data types, including mesh, material, texture, and skeletal motion information. Animation data in FBX files is typically stored in keyframe format, with the position, rotation, and scale of each joint stored for each frame of animation [25]. They are therefore ideal for use in video games and computer graphics. In addition, FBX files can be imported into other software programs that accept the FBX format from Autodesk software programs [26].

Biovision Hierarchy (BVH) file format a file format commonly used in motion capture to store skeletal data [27]. This file format consists of ASCII text with a time-framed sequence of different specifications for subsequent poses. The first part of the ASCII text specifies the initial pose of a human skeleton. The hip joint is designated as ROOT in the first section of a BVH file, preceded by the keyword HIERARCHY, indicating that it has no progenitor joints. It serves as the parent joint and as the child joint of a nested construction [28,29].

Comma-Separated Values (CSV) is a file format used to store tabular data [30]. In the context of motion capture, CSV files can be used to store motion data in a format that can be easily imported into 3D animation software. CSV files typically contain a series of rows, with each row representing a frame of the animation and each column representing the position, rotation, or scale of a particular joint in the skeletal structure. The data in each row of the file contain three columns (X, Y and Z coordinates) separated by commas. The name of this file format is derived from the fact that the fields are separated by commas. In most cases, the data is simply entered into a text file as ASCII numeric values separated by commas [31].

3) Refined skeleton: The refined skeleton model is used to correct or refine certain minor motion errors by adjusting the keyframes for each joint in the skeleton. This process can be done using certain 3D programs such as Autodesk Maya, Blender, 3D Studio Max, ZBrush, Adobe Dimension, Cinema 4D, Sense, Houdini etc.

Knowledge of human anatomy is crucial in this process so that the joints of the skeleton can be adjusted as desired. Moreover, keyframing, graph editor for animation and rigging techniques like Euler filter, Butterworth and noise reduction are also important to minimize the anomalies in the skeleton.

Maya is a 3D modeling, animation, and rendering software developed by Autodesk [32]. It is widely used in the film and television industry for creating complex visual effects and character animation. Maya provides a wide range of tools and features for modeling, animation, texturing, and rendering, including support for advanced shading and lighting techniques such as physically based rendering (PBR) and high dynamic range (HDR) imaging.

Blender is a free and open source 3D software known for its versatility and ease of use [33]. It offers a similar range of tools and features as Maya, including support for advanced shading and lighting techniques. Blender is widely used in the gaming industry for asset and environment creation, and in the film and television industry for visual effects and animation.

3D Studio Max is a 3D modeling, animation, and rendering software developed by Autodesk [34]. It is similar to Maya in terms of tool selection and features, but is more focused on architectural and engineering visualization, as well as product design and prototyping. 3D Studio Max also provides support for advanced shading and lighting techniques and is commonly used in the architecture and engineering industries to create 3D visualizations of buildings and other structures.

Other popular 3D software packages include Cinema 4D, Houdini, and ZBrush, all of which have their own strengths and weaknesses depending on the specific needs of the user. In conclusion, the choice of 3D software largely depends on the specific requirements of the project and the skill level of the user. Maya, Blender and 3D Studio Max are all popular programs with their own unique features and capabilities.

4) Evaluation: a heuristic evaluation is proposed to evaluate the review of the created motion templates. Heuristic evaluation is one of the usability engineering techniques used to identify usability problems in user interface design so that they can be fixed during an iterative design process. The goal of heuristic evaluation is to identify usability problems in a user interface design so that they can be fixed during an iterative design process. It is the most widely used inspection method; it is inexpensive, intuitive, and easy to use compared to other evaluation methods, and it does not require pre-planning [35]. In heuristic evaluation, the interface is examined by a small group of evaluators and checked for compliance with established usability guidelines. According to Nielsen [36], the recommendation for a heuristic evaluation is three to five people. A heuristic evaluation session for a single evaluator typically takes one to two hours. For larger or more complex interfaces with a significant number of dialogue pieces, longer evaluation sessions may be required; however, it would be preferable to break the evaluation into numerous smaller sessions, each focusing on a different aspect of the interface. The main goal of heuristic evaluation is to identify usability problems in user interface design using ten (10) established heuristic principles [37].

Heuristic evaluation is a testing method based on the characteristics of reusability of the system in terms of user interface design, which enables fast and effective problem solving and decision making. Heuristic evaluation is an approach used in this case to identify a set of usability criteria of the motion templates and 3D model for FDs, for example, in cases where the criteria do not meet user requirements. The heuristic evaluation is used to successfully improve the design. By having the design perform a series of activities, the evaluator can assess how well it meets the standards for each stage [38]. In the testing in this application, heuristic evaluation is performed in accordance with the ten Nielsen principles, which include visibility of system state, consistency with the real world, user control and freedom, consistency and standards, error prevention, recognition, flexibility and efficiency of use, aesthetic and minimalist design, helping users detect, diagnose, and fix errors, and help and documentation. The authors plan to evaluate the application using heuristics, which is supported by the above description.

The goal of the heuristic evaluation is to identify as many usability issues as possible in the development of the motion templates and 3D model character for FDs. The feedback from the experts is important to design and develop good motion templates and 3D model characters for FDs. To achieve this, a heuristic evaluation procedure is performed in this step:

a) Distribute an online questionnaire and video clip via email before conducting a testing session.

b) Schedule a 2-hour appointment with the experts to conduct the assessment.

c) The experts provide their feedback via online questionnaires.

d) The results obtained are analysed and used to develop a framework and prototype.

In summary, heuristic evaluation is the most widely used inspection methodology; it is inexpensive, intuitive, and easy to use compared to other evaluation methods, and does not require advance planning [35].

III. Data Collection and Analysis

MoCap can generate raw FD motion data based on expert movements. The trajectories of the motion data can be collected and analyzed in a variety of file formats such as FBX, SKL, BVH, CSV, etc., which can be used in 3D software. Observing the keyframes for each motion is critical to ensure that the motion data is rendered as accurately as possible with few anomalies. Having the correct and accurate motion data is important for creating motion templates that can be used in a variety of areas.

Once the motion templates are created, the verification analysis of the created motion templates can be performed to maintain the level of efficiency, accuracy and satisfaction. The appropriate tool or procedure to verify the created motion templates is heuristic evaluation. The data collected by the FDs experts can be analyzed to verify the created motion templates.

In order to use the motion templates in certain platforms such as virtual reality, augmented reality, animation, simulation, games, etc., verification analysis must be performed for FDs motion templates with 3D characters.

The evaluation of VR, AR, animation, simulation, and game platforms can also be tested using the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). TAM and UTAUT are both widely used models in the field of technology acceptance and adoption.

TAM is a theoretical model that explains how users perceive and adopt new technologies [39]. The model was originally proposed by Davis in 1989 and later modified by Venkatesh and Davis in 2000. According to TAM, two main factors influence user acceptance of technology: perceived usefulness (PU) and perceived ease of use (PEOU) [40]. PU refers to the extent to which a user believes that using the technology will improve his/her job performance, while PEOU refers to the extent to which a user believes that using the technology will be easy and effortless. The model suggests that PU and PEOU are the most important determinants of a user's attitude toward technology, which in turn affects his or her intention to use it [41].

UTAUT is a model that explains the factors that influence user acceptance and use of technologies [39]. The model was developed by Venkatesh et al. in 2003 [42] and is based on four key factors: performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC). PE refers to the extent to which a user believes that using the technology will improve hisor her job performance, while EE refers to the extent to which a user believes that using the technology will be easy and effortless. SI refers to the extent to which a user believes that influential people in his or her life believe that he or she should use the technology, while FC refers to the extent to which a user believes that he/ she has the resources and support necessary to use the technology [42].

IV. Expected Results and Discussion

By implementing the approaches proposed in this research, the expected results can be presented and discussed in detail.

Using the proposed framework, the digitization of different types of FDs can be implemented using MoCap. MoCap technology captures movements with high precision, allowing detailed analysis of the specific body movements and gestures characteristic of FDs. This information can be used to create templates for movement patterns that can be used as references by dancers, choreographers, and researchers [16]. The proposed framework provides suggestions and guidelines for conducting research to create movement templates for FDs.

Moreover, the creation of motion templates for FDs is very important for the future generation. With the motion templates, this kind of valuable intangible cultural heritage can be preserved, conserved, and bequeathed to future generations [43]. Preservation, conservation, and inheritance can be done through various platforms such as virtual reality, augmented reality, simulation, film, animation, games, e-learning, etc. The representation of FDs on these platforms may be able to attract people and introduce them to FDs.

The movement templates can also be used to standardize the teaching and performance of folk dances. By creating movement templates that represent the correct movements and gestures, dancers can learn the dances more efficiently and accurately. This can also help maintain consistency in performances by ensuring that the dances are presented in the same way each time they are performed [16].

At the same time, the movement templates of local FDs can be copyrighted to formally register them as local intangible cultural heritage. This is because the appearance of the motion templates shows their uniqueness and innovativeness compared to the existing local FDs.

It may also be associated with collaboration and cooperation with other third parties. In many cases of local FDs, the experts are outsiders or come from different organizations. In addition, the movement templates created may themselves attract the creative content industry. This may provide an opportunity for commercialization of the created movement templates.

V. Conclusion

This paper presents and discusses in detail the framework proposed in this study for the creation of movement templates of FDs with MoCap for the preservation and conservation of intangible cultural heritage. This framework includes conducting acquaintance meetings, procedures and approval, interviews and implementing experiments and proposed workflow. The findings from this framework are important and inter-relevant to obtaining the desired information.

The acquaintance meetings can be in the form of documentation and identification of experts that are important to gather the information about the local FDs present in certain areas. Letter of intent for conducting the research at the potential sites/locations, Invitation letter for conducting the fieldwork, Request for Verification of Motion Templates and Application for copyright are important to ensure the eligibility of the research conducted especially when law and confidential issues are involved. Meanwhile, the interviews are also important to get an overview of the types of FDs studied such as background, history, founders, and types of movements. Clarification of the purpose of the study and the experiments to be conducted can also be discussed with the experts. The workflow proposed in this study includes MoCap, skeleton generation, refined skeleton, and evaluation models.

For future work, this study is willing to apply the research approaches proposed in this paper to build the motion templates for local FDs in Malaysia. In Malaysia, FD has been registered and categorized as a performing art under Intangible Cultural Heritage. There are many FDs in Malaysia such as Tarian Gamelan, Tarian Piring, Tarian Zapin, Tarian Mak Yong, Tarian Sumazau, Tarian Ngajat, Tarian Kipas, Tarian Kathak, Tarian Kuda Kepang and others. It is expected that the implementation of the familiarization meetings, procedures and approval, interviews, experiments, and framework will fulfill the goals of facilitating the digitization of FDs and the preservation and conservation of this type of valuable intangible cultural heritage.

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