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DANCING INTO THE DIGITAL AGE: PRESERVING INDIAN CLASSICAL DANCE NARRATIVES THROUGH VIRTUAL AVATARS

Suma Dawn [1], Monali Bhattacharya [2]

[1] SMIEE, Department of CSE & IT, JIIT, Noida, India
[2] Prof & Add. Dean, Department of Humanities and Social Sciences, JIIT, Noida, India

Corresponding Author
Suma Dawn, suma.dawn@jiit.ac.in

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ABSTRACT

In this work, we explored methods for expressing dance narratives in a sequence on a virtual avatar, particularly in the context of Indian classical dance styles. This study has many different goals. First of all, it would aid in the preservation of multiple dance practices that are rapidly disintegrating since there aren't enough learners to impart lessons to them. Second, it may inspire a younger audience to be more engaged in discovering more about their cultural heritage by recasting it into a format that is easily accessible to them and can be valuable. Furthermore, this research will facilitate the organization of dance subtleties' morphology as well as their translation, retrieval, and storage processes.

The aforementioned requirements, which are ontological and resource-intensive, would aid in digitizing vintage dance forms, making it easier to navigate information heading onward, including comprehending meaning, translating it into other languages, using rhythm, and other labour-intensive operations. This paper includes an examination of several approaches and strategies that are currently in use and could potentially be implemented in future endeavours for the translation, conservation, and preservation of dance narratives.

This research investigates the process of transforming dancer-choreographer stories into inanimate objects and virtual characters. It aims to explore animation techniques for converting Indian dance forms into animated narration, preserving cultural heritage, understanding emotions in animated sequences, and mapping body movements to capture dance structures' essence.

Keywords: Dance, Animation, Cultural Translation, Narration, Storyboarding, Motion Capture, Pose and Posture, Emotion Depiction, Pure Dance Structure, Dance Ontology, Model Fitting

1. INTRODUCTION

Digital dance movement creation and understanding is an interesting computational task. Dance is used for the narration of a story. A story narration has multiple elements such as (i) the setting of the story – the geographic location of narration, time duration, and weather conditions, social conditions, mood or atmosphere, and ambiance of the narration; (ii) Characters involved – say protagonist, antagonists, side characters, etc., and their characteristics; (iii) Plot and Conflict; (iv) Point of view i.e., the perspective from which story is narrated; and (v) Theme. All these are mandatory requirements for story narration.

Currently, dance morphology, related nuances, its elements, and usage are not streamlined and not much explored by the research community [1]. Also, such streamlining will help in storage, retrieval, and other activities that may be resource and data intensive. Digitizing and presenting the traditional form to the generation of people, that is always using smartphones and attracted by innovative methods of representation, can help in the spread of the devolving and diminishing aspects of traditional dance narrations and forms [2], [3].

In this work, we are presenting the various methods for translating from a dance narration to an animated sequence, while capturing the essence of the dance itself. Such a translation form will help not only in the preservation of the fast-devolving and ebbing cultural art forms but also in accumulating these to help in their diversification and encouraging the youth to know, learn, and append to these cultural art forms. Motion retargeting is crucial in fields such as animation, virtual reality, and robotics, where realistic and naturalistic motion is required for characters and objects.

2. OBJECTIVES OF THE STUDY

This research probes the mechanism of conversion of a story choreographed by dancers to project on inanimate objects and present it on virtual characters. The following are the objectives of this study:

1) Studying the techniques used in the animation industry for the conversion of motion of animate objects to inanimate virtual objects.
2) To find the possibility of using the available techniques to convert Indian dance forms into animated narration, thereby endeavoring preservation of the basics of cultural heritage related to the Indian dance forms to imbibe further interest of the younger generation to pursue these art forms.
3) Understanding the various emotions that can be portrayed in the animated sequences.
4) Mapping body movements and postures to capture the essence of pure dance structures.
5) Helping with preserving pure dance structure for storage, and retrieval to increase interest in learning pure dance forms.

3. NARRATION DEPICTION REQUIREMENTS

A good story needs to be converted into a script to present to various audiences such as audio listeners; short stories, comics, novel readers; movie audiences; theatre audiences, etc. The requirements may include dialogue, action, timing, scene description, voice-over, effects, etc. The generic transformation from a narration to a virtual sequence i.e., animation may be performed (i) by imaging a particular movement pattern and choreography and then converting the same to animation, and (ii) by capturing the actual motion performed by actors using various sensors and then mapping the same sequences to the virtual character(s). Modules for conversion are depicted in Figure 1.

Figure 1

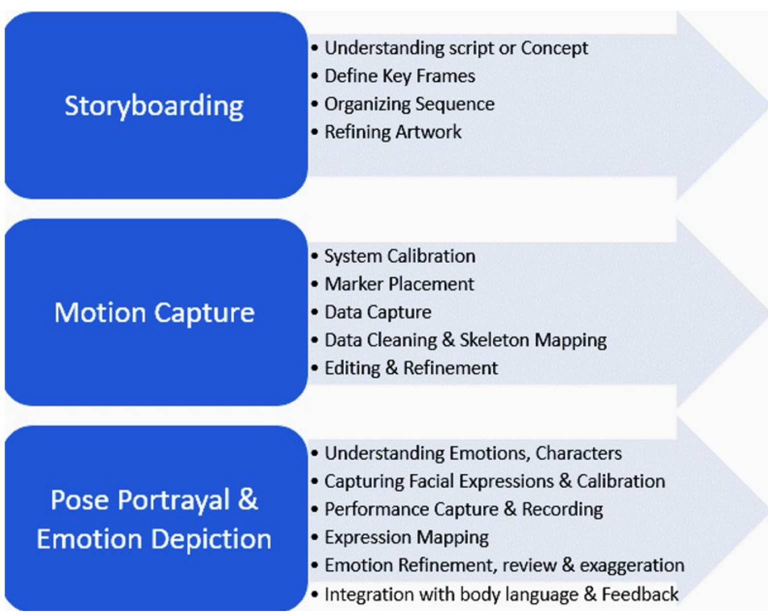


Figure 1 Narration Requirements

3.1. STORYBOARDING

Storyboard is a classic animation tool to help creators to organize scenes. It consists of a series of images or illustrations. It presents a process of pre-visual thinking of scenes. Arrow markings may be used to depict the sequence of story depiction. Conversion from a story to a comic script may be performed by understanding the script, appending appropriate characters, and then finally applying animation sequences to the characters. This conversion is shown in Figure 2.

Figure 2

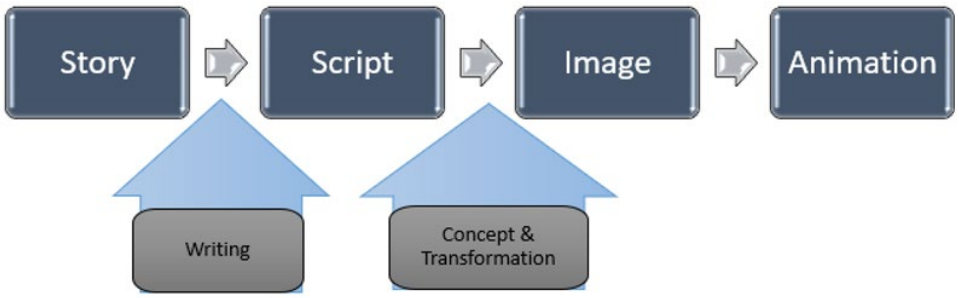


Figure 2 Story to Animation Conversion.

Storyboarding is a crucial step in the pre-production phase of filmmaking, animation, and even project planning for various types of media and presentations. It involves creating a visual representation of a narrative, scene by scene, to help plan the production and visualize the flow of the story.

3.2. MOTION CAPTURE

Usually, animated choreography can be done in two forms [4] - [6] – (i) Based on priorly defined poses i.e. body-centered approach and (ii) rule-based auto transformation to modify body poses according to formal principles i.e., machine-like controlled. Digitally, motion capture involves sensing, digitizing, and recording the object in motion. It also allows for the computation of the position and orientation of points on the body, which could be calculated from the stereographic projection of the point. The transformational hierarchy behavior of the skeletal data structure allows for the whole structure to move appropriately.

Figure 3

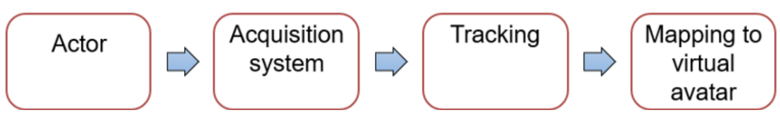


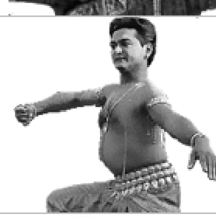
Figure 3 Module for motion capture of object

Character control for motion editing can be performed by forward and inverse kinematics. Translation from a single pose depiction from an actor to a virtual character is direct and based on the transformation points or the feature points that can be easily mapped. However, a continuous motion depiction is usually difficult as direct mapping of every movement may not have been precisely captured or due to problems in mapping features to animation parameters. The primary operations can be thought of as each pose presented by the actor or actors. Depictions such as dance, fight sequences, and other complex movements require multiple set of movement concatenated together in a particular predefined sequence. These concatenations may require interpolation of joint curve parameters that use space-time constraints and inverse kinematics to generate seamless and dynamically feasible transitions between motion segments.

3.3. POSE PORTRAYAL AND EMOTION DEPICTION

The pose of a virtual character consists of the scalar values for all of the parameters of the character at a given instant [7], [8]. The choice of values for these parameters, which represent a particular pose form the basis for editing and their particular operations, allow for alterations. Typically, in motion editing, the size of the character does not change, since the character is made up of rigid linked bone structure. Though each motion can be depicted concerning the root, the hierarchical representation of skeletal may lead to the creation of dependencies between different parameters that are non-intuitive [9] – [11]. Motion databases and pose databases exist and may use kinematic chains having a tree data structure. Some of these are depicted in Table 1.

Table 1 Different forms of Representations: A dancer showing the 9 Rasa (emotions), Dance Emotion Depiction and known static postures

Navarasa	Context	Example
Sringara	Love, Delight Attractiveness	
Haasya	Laughter, Mirth, Comedy	
Karuna	Compassion, Sorrow, Mercy, empathy	
Raudra	Fury, Anger	
Veera	Heroic mood	
Bhayanaka	Horror, Terror, Fear	

Bibhatsa	Disgust, Aversion	
Adbhuta	Wonder, Amazement	
Shantam	Peace	

Table 2 describes the various expressive elements of the possible static postures.

Table 2 Expressive Elements of Static Posture.

Emotion	Frequent posture features
Anger	Head backward, no chest backward, no abdominal twist, arms raised forwards and upwards, shoulders lifted
Joy	Head backward, no chest forward, arms raised above shoulder and straight at the elbow, shoulders lifted
Sadness	Head forward, chest forward, no abdominal twist, arms at the side of the trunk, collapsed posture
Surprise	Head backward, chest backward, abdominal twist, arms raised with straight forearms
Pride	Head backward or lightly tilted, expanded posture, hands on the hips or raised above the head
Fear	Head backward, no abdominal twist, arms are raised forwards, shoulders forwards
Disgust	Shoulders forwards, head downwards
Boredom	Collapsed posture, head backwards not facing the interlocutor

Apart from these forms of depiction, close-ups of facial expressions can be used to depict six common expressions. These include - joy, sadness, anger, surprise, fear, disgust. For easy manipulation via computers, a coding system, called the Facial Action Coding System (FACS) is used. The FACS acts as a common basis for describing and communicating human facial expressions. It is also used as a basis for designing characters animation systems [13], and facial expression recognition on scanned 3D faces. Conversions between these 6 expressions are easily performed by manipulation between the features used to depict these emotions.

Table 3 The first six rows explain the expressive features of arm movement, and the next five expound the frequent adaptors involved in specific emotional states.

Anger	Lateralized hand/arm movement, arms stretched out to the front, largest amplitude of elbow motion, largest elbow extensor velocity, highest rising arm
Joy	High peak flexor and extensor elbow velocities, arms stretched out to the front
Sadness	Longest movement time, smallest amplitude of elbow motion, least elbow extensor velocity
Anxiety	Short movement times, constrained torso range of motion
Interest	Lateralized hand/arm movement, arms stretched out to the front
Fear	Arms stretched sideways

Anxiety	Touching or pulling the hair, plucking eyebrows, wriggling or interlocking the hands, opening and closing the fist, aimless fidgeting, hiding the face
Inhibition	Touching or pulling the hair, stereotyped and unnecessary movements, withdrawal movements, general motor unrest
Depression	Hiding and withdrawal gestures
Pride	Arms crossed in front of chest
Shame	Touching or pulling the hair, plucking eyebrows, wriggling or interlocking the hands

However, going by the usage of these facial expressions in today's animations, there are many dimensions of happiness or joy being depicted as compared to anger and disgust being depicted. While most story narrations have critical changes in the storyline due to such emotional requirements, depiction of these expressions in the character's face had not shown with such high dimensionality. Most movies have less of facial expression of sadness, anger and the so-called negative emotions. Action sequences and character group dynamics now form the major bulk of the movie narration. Close-ups of multiple dimensions of positive emotions such as joy are shown in various forms however, depiction of sadness, and anger do not have much depiction in the animations. Further, for depiction of the other micro expressions, though can be expressed by posture and gesture, expression via just facial expression has not been much explored in animations.

3.4. EXAGGERATION PORTRAYAL

Exaggerated expressions enhance the emotion portrayed and recognition and are known to produce higher emotional-intensity rating [19], [24]. Exaggeration is usually depicted in the facial expression. Though the viewer knows that such a portrayal of emotion is physically impossible, nonetheless, this exaggeration finds acceptance due to its usage for portrayal and impact on the viewer.

In the context of Indian Classical Dance, dance is divided into three distinct categories as mentioned in various treatises such as 'Natyashashtra', and 'Abhinaya Darpana' amongst others. These broad categories are Natya, Nritya, and Nritta. These treaties deal with many issues of dramatic compositions such as the construction of the stage, musical requirements, costumes, make-up, space properties and analysis, and codes of body movements, including 'pada bheda', 'shiro bheda', 'anga bheda', 'griva bheda', 'anga sanchalan', 'bhakya sanchalan', 'pada sanchalan', 'hasta mudra', etc. Depiction of a scene would require a defined sequence of poses performed in a constrained rhythm. These indicate intricate footwork in complement with other body postures and facial expressions. In the Indian classical dance forms, there are 9 distinct emotions as stated in the treatise. These, apart from movements and poses, help in characterizing emotions.

3.5. FLUIDITY OF MOVEMENT

The depiction of movement in an animated sequence must be fluid. A direct usage of key frames for rendering movement can lead to rendering of a non-continuous set of movement. A fluid movement may be characterised by two basic properties. Firstly, the movement each part or joint of the body involved in the motion is fluid. This is based on the physical requirements and properties described by the body mechanics themselves. Secondly, the movement propagates along the associated body parts as per the construction of the body and the concerned kinematics leading to the trajectory of the body-part movement.

The loss of fluidity in movement depiction can lead to wrong or incomplete understanding of the narration imitation; and the narration may lose its aesthetically pleasing qualities. To reduce such blunders, certain computer graphics relevant techniques such as example-based interpolation of character motion [7], staggered poses [8], a Mass-Spring-Damper Model [9] etc., are available.

3.6. MOTION OPERATION

Translation from a single pose depiction from actor to a virtual character is direct and based on the transformation points or the feature points that can be easily mapped. However, a continuous motion depiction is usually difficult as direct mapping of every movement may not have been precisely captured or due to problem in mapping features to animation parameters.

The motions can consist of different set and number of operations. The primary operations can be thought of each pose presented by the actor or actors. These positions or poses of movements can be combined using operations such as union, intersection, and differences. These operations can be singular in nature such as warping the motion curve i.e., performing same deformation across all the features. Motion operations may be binary, in which operation between two motions is required. Such binary operations have applications in computer fight games, virtual reality environments, etc. Multiple operations are required in applications that use partial blending of two or more motions. Walking uses different forms of motions of torso, separate type of actions of legs and hips, radial motion of arms, etc. Such applications use multiple types of blending between motions to depict a particular action. Smoothening the resultant motions of different body parts is required to present natural looking movements of actors. Such operations and operations such as noise removal, outlier point's motion removal, etc require filter capable of such smoothening.

Depictions such as dance, fight sequences, and other complex movements require multiple set of movement concatenated together in a particular predefined sequence. These concatenations may require interpolation of joint curve parameters that used space-time constraints and inverse kinematics to generate seamless and dynamically feasible transitions between motion segments. This was useful for creating longer movement sequences.

Blending operations are used to combine movements having different characteristics in which the parameters of the movements may have wide-range variation. This may require changes in kinematic constraints or re-parameterization of motion constraints [11].

3.7. COSTUME AND MAKE-UP

Dance depicts a narration involving some characters, environments, chronology, eons, duration, situations, etc. A dance performance on stage requires depiction of emotions and poses to a mass of audience who are seated as some distance from the artist. Hence, costumes and make-up requirements may be very specific as per the depiction elements. Accordingly, the way a fabric hangs or moves on the dancer is important. Most Indian dance forms have specific costumes related to the specific dance styles. The costume parameters include texture, colour, material type, construction form, etc. Make-up as per the requirements of the characters is important as they enhance the character's attributes, environment condition, situational requirements, etc.

Translation of make-up from real character to an avatar is easier as it involves usage of colours and light parameters at various areas on the face of the avatar. If the face is depicted by a 3D form, the skin attached to the face can be coloured and shaded as per light parameters. The figure, Fig. 6, shown below, depicts the usage of costumes, make-up, facial exaggeration, etc., that can be used in various dance narrations.

Figure 4

Figure 4 Usage and importance of make-up and costumes.

Curtsey: https://www.youtube.com/watch?v=-o3InQC1EWM, https://www.youtube.com/watch?v=PqRXDaHXE6A,

3.8. MOTION RETARGETING

Motion retargeting is a technique used to convert motion data from one source to another, often applied in various fields such as animation and computer graphics. When converting video to animation using motion retargeting, the process typically involves the following steps:

Figure 5

Figure 5 Generic Steps Followed in Motion Retargeting

Firstly, motion capture or video input is required. The process starts with either motion capture data from a live actor or video footage of a person or object moving. This is followed by character rigging. While working with animation, a character rig is needed that matches the proportions and joint structure of the subject in the video or motion capture data. This rig serves as the skeleton onto which the motion will be retargeted. The third step involves retargeting process. This involves matching skeletons and inverse kinematics. Skeleton of the character must be ensured and rig matched as closely as possible to the skeleton used in the motion capture or video source. The motion data (keyframes, joint rotations, etc.) from the source (video or motion capture) needs to be mapped onto the corresponding joints of the character rig. This mapping process involves adjusting for differences in joint positioning and scale between the source and target skeletons. In some cases, inverse kinematics can be used to further refine the motion on the character rig, allowing for more natural movement. Following this fine-tuning needs to be performed. After the initial retargeting, fine-tuning is often required to address any discrepancies or artifacts that may have arisen during the mapping process. This step ensures that the animation looks smooth and realistic. The final step involves rendering. Once the motion has been successfully retargeted and fine-tuned, the animation can be rendered out into the desired format, whether for further editing or final production.

Tools like motion capture software, animation software (e.g., Blender, Maya, Unity), and specialized plugins or scripts are commonly used in this process to facilitate accurate motion retargeting. The goal is to preserve the essence of the original motion while adapting it to fit the characteristics and style of the animated character or object.

Motion retargeting involves several key components and processes that work together to transfer motion data from one source to another, typically from a source character or object to a target character or object. The architecture overview of motion retargeting is as follows.

Figure 6

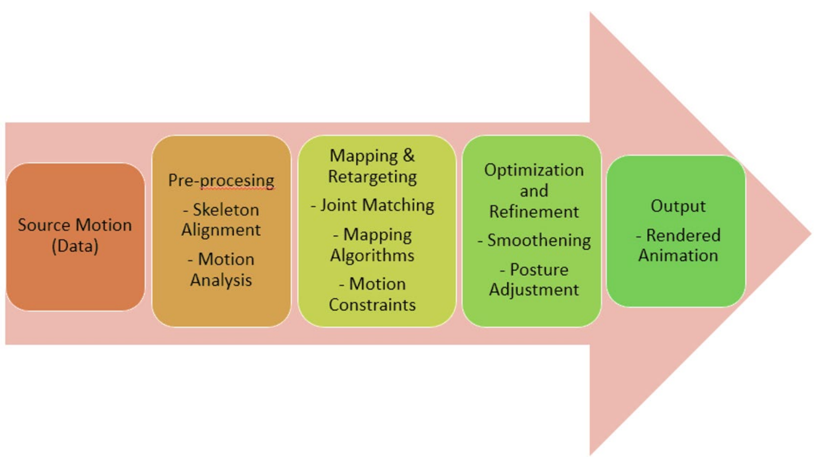


Figure 6 Animation Retargeting Process

1) Input Data

- **Source Motion Data:** This can come from motion capture systems, video recordings, or any other form of motion data acquisition. It includes information such as joint rotations, positions, velocities, and possibly muscle activations depending on the level of detail.
- **Target Skeleton/Rig:** The structure onto which the motion will be retargeted. This is typically a hierarchical skeleton with joints and bones that define the movement capabilities of the animated character or object.

2) **Pre-processing**
   - **Skeleton Alignment:** Ensure that the joint structure and hierarchy of the source and target skeletons are compatible. This often involves matching joint names and orientations to facilitate accurate mapping.
   - **Motion Analysis:** Analyze the characteristics of the source motion data, such as joint angles and velocities, to understand how to best map it onto the target skeleton.
3) **Mapping and Retargeting**
   - **Mapping Algorithms:** Techniques such as inverse kinematics (IK), forward kinematics (FK), or blending algorithms are used to map the motion data from the source to the target skeleton.
   - **Joint Matching:** Determine correspondences between joints in the source and target skeletons. This ensures that each joint in the target skeleton receives appropriate motion data from the corresponding joint in the source.
   - **Motion Constraints:** Apply constraints to ensure that the retargeted motion respects physical limits and anatomical constraints of the target skeleton. This prevents unnatural movements and improves realism.
4) **Optimization and Refinement**
   - **Smoothing and Filtering:** Apply techniques to remove noise or jitter from the motion data, ensuring smooth transitions between keyframes.
   - **Posture Adjustment:** Fine-tune the retargeted motion to improve posture and overall animation quality. This may involve adjusting joint angles or positions to better fit the character's design or style.
5) **Output**
   - **Rendered Animation:** The final retargeted motion data is output as keyframes or animation curves suitable for rendering in animation software. This output can then be used for further editing, integration into a larger project, or direct use in production.
   - Tools and Techniques
   - **Motion Capture Systems:** Hardware and software used to capture motion data from real-world actors or objects.
   - **Animation Software:** Tools like Autodesk Maya, Blender, or MotionBuilder that provide features for character rigging, animation editing, and rendering.
   - **Plugins and Scripts:** Additional tools or scripts developed to automate or enhance specific aspects of the motion retargeting process, such as IK solvers or motion blending algorithms.

Certain challenges are present in motion retargeting such as - Articulation differences, data quality, and Realism vs Artistic styles. There may exist variations in joint articulation and structure between source and target skeletons can complicate accurate motion mapping. Also, poor-quality motion data or noise can affect the fidelity of the retargeted animation. Further, balancing the need for realistic motion with the desired artistic style of the animation.

Motion retargeting is crucial in fields such as animation, virtual reality, and robotics, where realistic and naturalistic motion is required for characters and objects. The architecture described above provides a framework for understanding how motion data is transferred and adapted across different skeletons or rigs.

4. PROPOSED DANCE TRANSLATION METHODOLOGY

The dance-to-animation conversion framework would require capturing of position of actors in the given stage (3D space), costume mapping, facial expression and pose capturing, mapping rhythm, etc. The basic motion capture form is shown in Figure 1.

Traditional motion capturing would employ a huge set of sensors and markers to enable this mapping from actors to their virtual avatars. An automated computational framework would require the model to comprehend, estimate, classify, and render the various gestures, postures, and formations based on physical constraints. It also requires an annotation for all possible set of movements. A codification system would have to be generated that can identify individual ‘mudras’ of body parts ranging from subtle to pronounced movements. Certain ontologies for dance exist and are being developed for the Indian Classical Dance forms too [12] – [18].

For a dance sequence to be recorded in its final animated form, the body movements have to be very clearly captured and defined. The combinations of various body-part movements can result in numerous possibilities for pose, position, emotion, and expression depictions. The captured content has to be constrained as per pre-defined ontologies and fit their structure parameters. Also, certain rule-based functions have to be generated that would help in mapping the dance pose formation to its avatar model. These reference-to-target alignments have to be evaluated, and corrections may be applied iteratively to fine-tune the model. The design methodology is shown in Figure 2.

The usual acquisition model is the motion capture system, using both wearable sensor-based and marker-based motion capturing. Other capturing devices such as Kinect Sensors or visual data may also be used. The spatiotemporal motion is captured; its reference model is recorded and used for the formulation of rules as well as for the extraction of dance elements. These elements are mapped with the ontology structures for further mapping and fitting the target (animated model). The final model is created using motion retargeting concepts. In this process, algorithms and techniques are used to map the motion data from the source skeleton onto the target skeleton. This includes matching corresponding joints, applying mapping algorithms (such as Inverse Kinematics or Forward Kinematics), and applying motion constraints to ensure realistic motion. Motion constraints play a crucial role in motion retargeting to ensure that the transferred motion remains realistic and physically plausible. Various factors such as joint limits, bone-length preservation, inverse kinematics constraints, smooth transitions, postural and physical constraints, Kinematic Constraints, and Foot Placement and Contact Constraints play important roles.

Joint rotations must be ensured to not exceed anatomically possible limits. For example, human joints have natural ranges of motion that should be respected to avoid unnatural poses. Maintaining the relative lengths of bones or segments in the target skeleton to prevent distortion is a common requirement. This is particularly important when retargeting motion to characters or objects with different proportions than the source. End Effector Constraints need to be defined to help maintain stable and realistic poses, especially for limbs and appendages. Motion smoothing will help blending between keyframes or applying filters to smooth out abrupt changes in motion, ensuring fluid and natural movement. Gravity and physics simulation must be integrated to showcase realistic physics into the motion retargeting process and ensure that movements appear natural and responsive to environmental forces like gravity or collisions. Pose constraints enforce specific poses or orientations of joints or body parts based on the intended motion style or character design to maintain consistency and aesthetic appeal in the animation. Kinematic Chains help maintaining the integrity of joint movements along kinematic chains (e.g., the spine, limbs) to ensure coordinated and anatomically plausible motion. Foot placement and contact constraints ensure that feet or other contact points maintain contact with the ground or other surfaces, enhancing realism and stability in locomotion animations.

After the completion of the retargeting, the output (target model) is then evaluated concerning the reference model using error estimators and correctors. After fitting the model and evaluating it so that the errors may be contained within an acceptable range, the final Target sequence is stored. The fitting may require multiple iterations of evaluation and refitting so that minimum error distances may be recorded between the actual movements and depiction to the virtual scene.

The standard acquisition approach is the motion capture system, which employs both wearable sensor-based and marker-based motion recording. Employing other capturing tools, like Kinect Sensors or visual data, is also possible. The spatiotemporal motion is recorded, and both the reference model and the dance element extraction process use this data to create rules. These components are mapped with the ontology structures for further mapping and fitting the target. (animated model). Utilizing error estimators and correctors, the Target model is then compared to the Reference model. The final Target sequence is stored after the model is fitted and evaluated to keep the errors within a reasonable range. Multiple evaluations and refitting iterations may be necessary for the fitting so that minimum error distances between the actual movements and depiction of the virtual scene may be recorded.

Figure 7

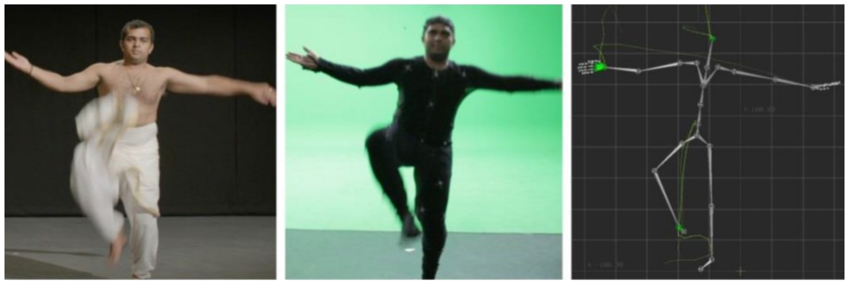


Figure 7 (a) Actual Dance. (b) Dance Captured in Mocap System, (c) Translation from Mocap to Stick Figure.

Motion acquisition can be made by mechanical, optical, and magnetic technologies or based on markers. It is used to create a representation to distill the motion of the dance/actors from their appearance and further encode it for analysis and processing. For use in animation, these representations must be mapped with the various principles of animation [4]. The acquisition allows for the creation of a motion database. The tracking is a much simpler process as it analyzes the position of various sensors throughout the sequence. The track maps may be pursued as skeletal diagrams, point clouds, or vertices within graphs.

The goal is to manipulate the motions performed by the 3D computer character. The fundamental requirement is to perform the stereographic mapping. Vectors from the cameras' focal point to the cameras' image place are found. The focal length of the camera, as the z-coordinate and the x, and y coordinates of the point on the image plane, is used by this vector. These vectors can intersect at the world point, which can be found easily with two cameras.

The character model must be very expressive and animatable in many ways, such as facial expressions and exaggeration, body movements, etc. Assuming that the virtual models are humanoid-like characters, the body movements can be related directly to the motion of their underlying skeleton structure. The skeleton structure should have the relevant characteristics of being rigid links that are connected in some constrained hierarchical representation to others by rotational joints. These joints do not translate in disjoint states but are restricted by the hierarchy and certain allowed degree of freedom (DOF) requirements. The entire skeletal representation has a global position and orientation. Its foundation is laid down by the rigid, connected parts that can pivot, twist and swing with respect to each other based on explicit constraints that prevent them from separating or having prohibited behavior. The DOFs give the position and orientation and allow movement of each bone in the body. If a movement is applied to any bone, the relevant constraints of the attached bones, too, must be recalculated.

The skeletal data structure's transformational hierarchical nature enables the entire structure to move appropriately. Additionally, it enables the computation of a point's position and orientation on the body using its stereographic projection. Calculating the center of the hand is necessary. Let v represent where the wrist joint—the hand's centre of rotation—is in relation to the hand's centre of mass. To compute the current world space coordinate, vw of the hand, concatenation of the transformation matrices of each joint between the point's origin and that of the root of the hierarchy is required and may be represented as:

$$vw = Tw(x,y)Rw(\theta w)TsRs(\theta s)TcRc(\theta c)TbRb(\theta b)TfRf(\theta f)ThRh(\theta h)v$$

In this composition, from left to right, the sequence of translations (T) and Rotations (R) are rigid transformations that are to be applied to the hand's base (h), bicep (b), chest (c), stomach (s), waist (w).

Translation from a single pose depiction from an actor to a virtual character is direct and based on the transformation points or the feature points that can be easily mapped. However, a continuous motion depiction is usually difficult as direct mapping of every movement may have yet to be precisely captured or due to problems in mapping features to animation parameters. Specific ontologies for dance exist. These include the notations used specifically for ballet annotation, such as Labanotation and Sutton Shorthand. For Indian traditional dance styles, however, some ontologies and annotations are also being established [19]– [22].

Figure 8

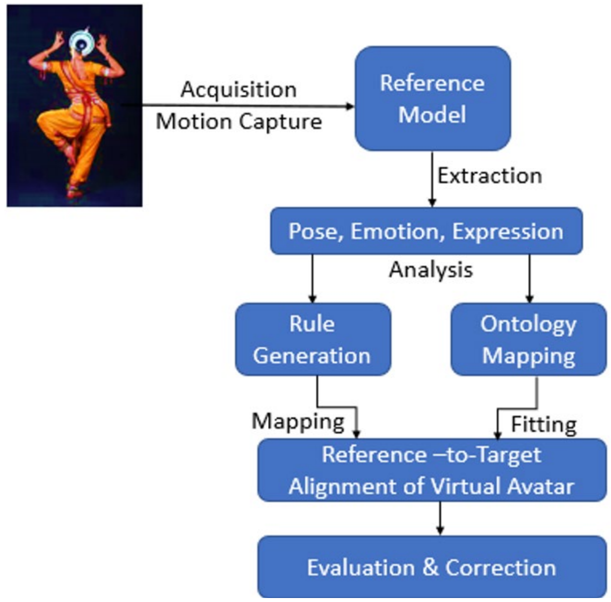


Figure 8 System Model for Translation from Actor-Based Dance Narration to an Animated Dance Sequence

5. CONCLUSION

This paper aims to investigate the requirements for converting live dance narrations into virtual avatars. The motivation behind this study is the need to preserve traditional Indian dance forms and promote their knowledge among the modern generation. The research explores various methods and techniques commonly used for translating live performances into virtual avatars, focusing on the representation of emotions, understanding and utilization of dance elements, and their ontology and morphology, to develop rules for virtual reconstruction of the dance narration.

The study also examines how to convert a choreographed dance story for projection onto inanimate objects and virtual characters, adapting it for performance stages, and depicting exaggerated emotions and their effects. Additionally, the paper considers animation methods, motion capture techniques, dance and staging nuances, and general narration requirements. Furthermore, it presents the methodology for applying translational functions and their computational requirements.

The paper explored various generic methods and techniques used in the translation of live characters into virtual avatars. Analysis of the translation of emotions from live performances to virtual avatars, ensuring that the emotional depth and nuances are retained was attempted. During this study, the key elements of dance, including gestures, movements, and expressions, and their roles in storytelling were deliberated upon. The study also examined the ontology (the nature of being) and morphology (the form and structure) of these elements to understand how they can be digitized effectively. Development of a set of rules and guidelines for accurately reconstructing live dance narrations into virtual formats were endeavoured. These rules consider the cultural and artistic integrity of the original performances were corroborated. The processes involved in converting choreographed dance stories for projection onto virtual characters and inanimate objects were enquired. The adaptation of these stories for different performance stages and settings were explored. The role of emotion exaggeration in dance and how it affects audience perception were recognized. The impact of these exaggerated emotions when translated into virtual avatars were also examined. Animation and motion capture methods suitable for this purpose were investigated. Further, the unique difficulty of capturing complicated dancing motions and expressions were discussed. Analysis of the effects and nuances of staging in live dance performances and how these can be replicated in a virtual environment were also initiated. The interplay of lighting, set design, and other staging elements in the virtual portrayal were considered. The requirements for effective storytelling in dance, both in live and virtual formats were studied. Narrative elements can be seamlessly integrated into virtual dance performances were explored. Computational methodologies required for applying translational functions were presented. The hardware and software needs for processing and rendering virtual dance performances were discussed.

By addressing these objectives, the paper aims to create a comprehensive framework for the virtual translation of traditional dance narrations. This framework will not only help in preserving the rich cultural heritage of Indian dance but also make it accessible and appealing to contemporary audiences. The insights gained from this study could also be applied to other traditional art forms, contributing to their preservation and modernization.

CONFLICT OF INTERESTS

None.

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