Title: *A Framework for Modeling, Analysis and Transcription of Bharatanatyam Dance Performances*

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Abstract: Indian Classical Dance1 (ICD), an ancient heritage of India, consists of visual (posture, movements, and expressions), auditory (music, tempo, rhythm, and intonation) information that has aesthetic and symbolic value. *Bharatanatyam* is one of the eight Indian classical dance forms. *Adavu*'s are the basic units of *Bharatanatyam* that are combined to create a dance performance. The dancer performs various gestures, postures and movements in synchronization with music. The objective of this research is to model, analyze and transcript the multimedia aspects of *Bharatanatyam Adavu*'s.

We build ontological as well as event based models of *Bharatanatyam Adavu*'s from the inherent structure of ICD and capture 1218 multimodal recordings of *Adavu*'s, performed by 10 trained dancers, using Kinect 1.0. The methodology of the work is based on the captured data and the model. Dance is closely bound to music in its structural discourse. Hence, we first analyze the accompanying audio (called *Sollukattu*) comprising beats and *bol*'s (utterances) and generate an automatic annotation of the audio with 87% accuracy. The audio annotation helps us to segment the video in a structured way. We also perform motion-guided segmentation of the video and synchronize the result of the audio and the video-based segmentation to get the Key Frames containing Key Postures (monetarily stationary well-defined postures). Gaussian Mixture Model (GMM), Support Vector Machine (SVM) and Convolutional Neural Network (CNN) classifiers are used on different features of Skeleton and RGB images for key posture recognition. We achieve recognition rates of 83.04%, 97.77% and 99.12% respectively using GMM, SVM and CNN. Next, we recognize *Adavu* as a sequence postures by using Hidden Markov Model (HMM) with 94.64% accuracy. Finally, we build a transcription system using the model and recognition system. It generates a parse-able XML for an *Adavu* using the well-known *Labanotation* notational system. We also create an annotated data set for *Bharatanatyam* and make it available for research: http://hci.cse.iitkgp.ac.in/.

We demonstrate an end-to-end work from data capture, to modeling, analysis and dance transcription. This is the maiden attempt to develop a composite framework for analyzing multimodal recordings of dance performances that leads to fairly good recognition rate.

Keywords: Multi-modal Analysis, Ontological Model, Kinect, Audio / Video Annotation, Beat Marking, Posture Recognition, Dance Sequence Recognition, Dance Transcription, Heritage Preservation, Indian Classical Dance.