

Chapter 1

Introduction

Research on recognition of hand gestures in dance is a challenging area in pattern recognition. Dance gesture recognition refers to the linguistic treatment of human motion where gestures are used to communicate drama artistically. One of the applications of this research is to create universal communication environment for a dance drama which is independent of the language of the associated song. Therefore, such a recognition system will help a viewer to understand the meaning of dance sequences irrespective of the language of the background song. It has also applications in self-assessment and e-learning of dances.

Among the research in recognition of dance gestures, Indian classical dances has also drawn attention among the researchers. There are eight different officially recognized classical dances in India. The two Indian classical dances where majority of the research on gesture recognition have been carried out are Bharat Natyam [19, 46, 63, 70] and Odissi [67, 68]. Sattriya dance is a 15th century major Indian classical dance form and one among the eight Indian classical dances. To the best of our knowledge, there is no significant research reported in the literature for recognition of gestures of Sattriya dance.

In the art of dance learning, hand gestures are first and the most important step to learn because of its flexibility and utility. This Sattriya dance uses of several hand gestures, most of them are similar to other classical dances which is performed by both male and female dancers. The hand gestures of classical dances are known as mudras, whereas they are known as hastas [7] in Sattriya dance. As mentioned in 'Sattriya Nrityar Rup Darshan' by Karuna Borah [7], there are seventy six hand gestures in Sattriya dance. Among them 29 are single-hand gestures and remaining 47 are combined hand gestures. The single-hand gestures

which are used in Sattriya dance are known as Asamyukta hastas. The name 'Asamyukta hasta' is the combination of two words Asamyukta, meaning 'single' and hastas meaning 'hand gestures'. The combined hand gestures are divided into Samyukta hastas and Nritya hastas. The Asamyukta hastas are considered as the basic set of hastas of classical dance and Samyukta hastas and Nritya hastas are derived from this basic set of Asamukta hastas.

The main focus of this work is on the basic set of Asamyukta hastas consisting 29 single-hand gestures of Sattriya dance. In hastas, the fingers play a very important role to represent different emotions artistically. The following research issues and challenges are identified based on the literature survey

- There is no dataset available for Sattriya dance hand gestures which is a major issue for the researcher working on recognition of Sattriya dance hand gestures.
- Hand segmentation is the most necessary phase in every hand gesture recognition system. It is the process to extract the hand region from the background. Segmentation of hand gestures in a complex background is still a challenging task.
- The image of a particular hasta may have wide variations due to position and angle of view of the camera. Therefore, a hand gesture recognition system which is invariant to different types of transformation of the hastas is a difficult task.
- The hastas may also vary from dancer to dancer. Incorporating these variation is also a difficult task.

1.1 Motivation

Sattriya dance is one among the eight officially recognized Indian Classical dance form. It is the only officially recognized classical dance form of the state of Assam of the North-Eastern region of India. Though the origin of this dance form can be traced back to 15th century, it gained wide popularity in India and abroad only after getting the official recognition as an Indian Classical dance form in the year 2000. The prime motivation behind this research is that there is no significant work reported in the literature in recognition of Sattriya dance hand gestures. It was also observed during our study that many hastas are similar with the mudras

1.1. Motivation

of other Indian classical dance forms but there are some representational differences.

Objective of this work is to develop a gesture recognition system to recognize Sattriya dance hastas from images with high recognition accuracy. Though our work will primarily aim towards recognition of Sattriya dance hastas, we strongly believe that the results will also be applicable in recognition of hand gesture of other dance forms. Also, it was observed during our study that 20 hastas are similar with other classical dances as recognized by famous Granthas (Epic) viz., Srihasta Muktawali, Natya Sastra, Sangeet Ratnakar and Abhinya Darpan(the Mirror of the gestures). For example, among the 29 Asamyukta hastas of Sattriya dance, 9 hastas viz., Ankusha, Ardhasuchi, Ban, Dhanu, Granika, Sasaka, Suchimukha, Tantrimukha and Urnanava hastas are not used in Bharatnatyam classical dance. Also, among the 20 similar hastas, Chatura, Kartarimukha, Sandangsha, Hangshamukha (ham-saya), Singhamukha hastas have significant representational differences with the hastas(mudras) used in Bharatnatyam classical dance [7]. Therefore, it is felt that existing recognition systems of Indian classical dance gestures will be of little use for Sattriya dance. It is also observed that there is no publicly available dataset of Sattriya dance hand gestures and creation of such a dataset will be great help to the research community in pattern recognition and related areas. This is the prime motivation behind this work.

The Indian Classical dance form have three major component! Nritya, Nritya and Natya [70].

- Nritya : It represent the abstract part of the dance. It is not related to any mood or meaning of the dance. Its purpose is to show the geometric patterns and complex rhythmic variations with respect to space and time.
- Nritya: This is the main dance component, mainly deals with the 'hastas' (hand gestures) and 'bhavabhinaya' (facial expression) and these are based on Classical music (taal and bool for Sattriya dance). Here meaning of songs are represented by the body language and express the internal feelings of the song.
- Natya: It contains all the information like dance, abhinaya, dialogue etc. Here dancers play the roles of characters and perform the dramatic story.

In the proposed work we will focus on Nritya part and give importance on different types of 'hastas' (hand gestures) of Sattriya Classical dance.

1.2 Objectives

The objective of this work is to develop a gesture recognition system to recognize the single-hand gestures of Sattriya dance from images with high recognition accuracy. The Ph.D research work proposes to achieve the following objectives:

- To develop a dataset of Sattriya dance single-hand gestures.
- Extraction of invariant features to represent Sattriya dance single-hand gestures.
- To develop a classification method for Sattriya dance single-hand gestures recognition.
- To develop a scheme to measure similarity or correctness of a candidate hand gestures with respect to a given set of standard Sattriya dance single-hand gestures.

1.3 Conceptual Framework

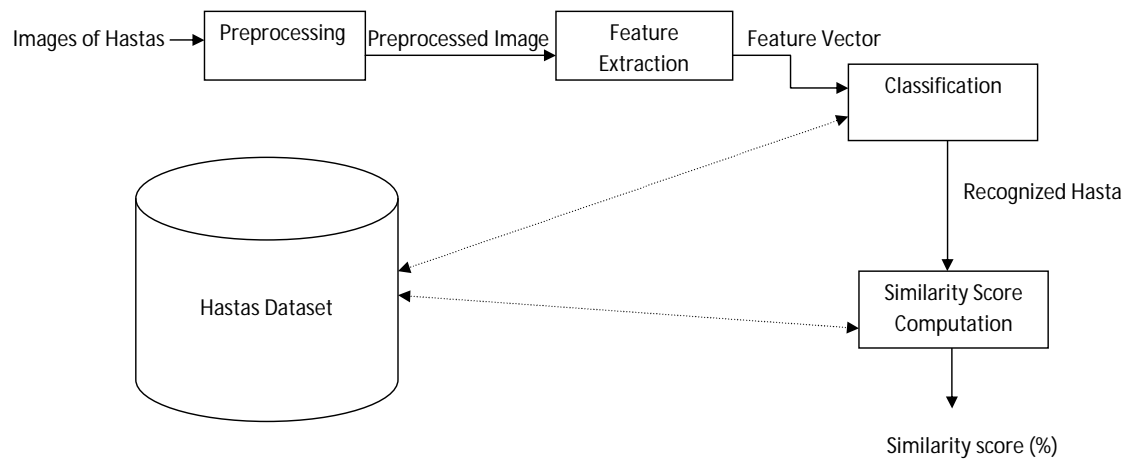


Figure 1-1: Conceptual Framework of the Proposed System

A conceptual framework of the proposed system is depicted in Figure 1-1 and described below:

1.3. Conceptual Framework

Input: The input to the system are the images of unknown (yet to be recognized) Sattriya dance Asamyukta hastas.

Preprocessing: Preprocessing involves removal of noise from the images of input hastas and segmenting the image to extract the hasta image from the background. Some existing techniques will be used in this step.

Feature Extraction: Extraction of invariant features from the preprocessed image to represent the hastas.

Classification: This is the final phase of gesture recognition. The main job of this phase is to understand the images. This phase consists of two sub phases: training phase and testing phase. For each classification methods, the database is trained with the 70 % instances (features extracted from the images) of the dataset. In the testing phase, the remaining 30% instances are used. In this research work, two types of classification methods have been proposed. One is two-level classification method and another one more than two level i.e., hierarchical (multilevel) classification method. In higher level, the input hand gesture images are classified into one of the groups where the input image matches the most. The hasta group is returned as the output of this step. In the lower level, the classification is narrowed down within the group towards recognition of individual hastas.

- **Two-Level Classification:** In this classification method, two phases training and testing are involved. In training phase, the twenty nine hastas are trained into three groups based on their structural similarity. In testing phase, the input hasta image first preprocessed, then sent to feature extraction step. Then, the input hasta is recognized as one of the three group at first level. At second level, the hasta is individually recognized from the database within the group.
- **Hierarchical Classification:** The Hierarchical classification perform hierarchically more than two level. In each level, the search space of the image is narrowed down until each individual hasta in the leaf node is recognized.

Similarity Score Computation: Here an Entropy based scheme to measure similarity or correctness of a candidate hand gestures with respect to a given set of standard Sattriya dance single-hand gestures within the class is calculated

Database: The database consists of the followings:

- **Hastas:** The hastas database consists of 1450 original images of hastas and additionally 43,500 images generated by addition of noise. For each

hasta, hu's seven invariant moment, Zernike moments, Legendre moments, geometric features and vision based features were extracted. The extracted features value are rotation, translation and scaling invariant. In addition, entropy of each class is also store in the database.

- **Metadata:** Annotated detail of the hastas are provided.

Output: Recognized hastas with similarity score.

1.4 Dissertation Contributions

The main contributions of the dissertation can be divided into four parts. The following subsections briefly outline the major contributions of the dissertation.

1.4.1 Creation of Sattriya Dance Single-Hand Gestures (SSHG) Dataset

The dataset contains 1450 images of 29 single-hand gestures of Sattriya dance. The images are captured using a digital camera in a uniform background and keeping fixed distance between the camera and dancers. Each of the hastas has 50 samples with their different angle of view of the camera. Primarily, background of the images were subtracted. Thereafter, the background subtracted images were preprocessed, filtered, converted to gray image, binary image and boundary image dataset. Additionally 43500 images were generated from these original 1450 images by adding different types of noise. For each original image 30 instances with noise are generated.

1.4.2 An Empirical Analysis of State-of-the-Art Classifiers for Recognition of Hand Gestures using Existing Features

In this part of work, an empirical analysis has been conducted to evaluate the performance of some existing classifiers on our SSHG dataset with moments and geometric features. In this experiment, three types of moments namely Hu's moment invariants, Zernike moments, Legendre moments and 14 types of geomet-

ric features viz., area, centroid, eccentricity, bounding box, aspect ratio, convex hull, diameter, Euler number, major axis length, minor axis length, orientation, perimeter, max intensity, min intensity are used. Five popular classifiers viz., K-NN, Bayesian Network, naive Bayes, decision tree and SVM are used to classify the Asamyukta hastas using the above features. Moreover, the SVM classifier is experimented using three types of kernel: Linear, polynomial and RBF kernel. The results show that the recognition accuracy for moment features is good but there are scopes to improve. It is also observed that the classification accuracy is better with moments than with geometric features. In order to improve the classification accuracy, we propose a two level classification scheme for recognition of Sattriya dance hand gestures on geometric features in the next section.

1.4.3 A Two-Level Classification Scheme for Sattriya Dance Single-Hand Gestures Recognition

In this part of the work, a two-level classification scheme for single-hand gestures (Asamyukta hastas/mudras) of Sattriya dance is proposed. In the first level, twenty nine classes of hastas are categorized into three groups based on their structural similarity. In the proposed method, Support Vector Machine [24] is used for the first level classification as it gives better result compared to other classifiers. In the next level, the individual hastas are classified within its belonging group using decision tree classifier. The classification accuracy for second level dataset is good but can be improved. The reason may be that most of the Asamyukta hastas are very similar to each other, so there are chances of mis-classification and hence low classification accuracy. Thus, in the subsequent section of the work we focus on the identification of more discriminant features and proposed a classification algorithm to improve the recognition accuracy.

1.4.4 A Hierarchical Classification Algorithm for Recognition of Sattriya Dance Single-Hand Gestures

In this part of the work, a hierarchical classifier using a set of vision-based structural feature are proposed. These vision-based features represent the shape of hand gesture images. Several algorithms are developed for extraction of these features from MAT images. Though these features are proposed for recognition of Sattriya dance single-hand gestures, they may also be applicable in similar applications. A new hierarchical classification algorithm using these features is

proposed. At each level in the hierarchy the search space is narrowed down until each individual hasta at lowest level in the hierarchy is recognized. Additionally, a scheme for measuring the correctness of Sattriya dance single-hand gestures using entropy measure is also proposed.

1.5 Organization of the Thesis

The thesis is organized as follows:

Chapter 1: Introduction

This chapter gives a brief introduction, explaining the motivation and objectives, and summarizes the main contributions of the thesis.

Chapter 2: Literature Survey

A comprehensive literature survey on dance gestures recognition has been conducted. The survey helped to identify the issues and challenges faced in this research. The literature survey on gestures taxonomy, applications, existing methods of gestures recognition with special emphasis on dance gesture recognition is presented in this chapter.

Chapter 3: A Dataset of Sattriya Dance Single-Hand Gestures

This chapter presents the development of single-hand gestures of Sattriya dance dataset and the organization of the images in the dataset.

Chapter 4: An Empirical Analysis of State-of-the-Art Classifiers for Recognition of Hand Gestures using Existing Features

In this chapter, an empirical analysis of 3 types of moment features and 14 geometric features of Sattriya dance single-hand gestures using five state-of-the-art classifier is presented.

Chapter 5: A Two-Level Classification Scheme for Sattriya Dance Single-Hand Gestures Recognition

In this chapter, a two-level classification scheme for single-hand gestures of Sattriya dance using geometric features is presented .

Chapter 6: A Hierarchical Classification Algorithm for Sattriya Dance single-hand gestures Recognition

In this chapter, a hierarchical classification algorithm using vision based invariant structural features has been presented. This chapter also presents an entropy based scheme for finding the similarity or correctness of a candidate hastas with respect to a given set of standard hastas.

Chapter 7: Conclusion and Future Direction

This chapter concludes the dissertation by summarizing the works done and also listing the possible further research in this area.