Chapter 3

Dataset Creation

This chapter presents a novel dataset for validation of any computer vision method for recognition of Sattriya dance hand gestures. The dataset fulfills all major requirements and has been established using five wellknown classifiers in the next chapter. A sample of the dataset is made available at $http$: $//agnigarh.tezu.ernet.in/ \sim sarat/resources.html$

Predominantly, hastas are symbolic hand gestures which are used during dance performance to convey various expressions. The hand gestures used in classical dance forms are known as mudras, whereas in Sattriya dance they are called as hastas. The dataset introduced in this chapter contains 1450 images of 29 hastas from six individuals. From each original image three images, a gray image, a binary image and a boundary images are created in the dataset. For each original image in the dataset thirty additional instances for the images are generated by adding Gaussian, Salt & Pepper, Speckle noise with different and also blurring the images. Finally, the dataset contains 44,950 (1450 original + 43,500 noise added) images. In addition to these images, the dataset is generated using feature extraction methods explained in the next Chapter. In this chapter, an overview of our approach used to create the Sattriya dance single-hand gestures image dataset is presented.

The rest of the chapter is organized as follows: Section 3.1 define the motivation of creating this dataset. The related Section 3.2 describes several available hand gestures dataset. Section 3.3 describes the detail of the development of the Sattriya dance single-hand gestures dataset. Section 3.4 reports an annotation database of these hastas to understand the meaning, uses and techniques to express the hasta and finally, the concluding remarks are given in Section 3.5.

3.1 Motivation

Datasets are important for validation of any method or technique. The effectiveness of a method or technique can be well judged using an unbiased, complete and correct dataset. Though several research works on recognition of hand gestures of Indian classical dance forms, particularly Bharat Natyam [19, 46, 66] and Odissi [67, 68] are available in the literature, but there is no dataset of hand gestures of these dance forms are available in public domain. Therefore creation of a dataset in this domain will benefit the research community working in this area. Also, Sattriya dance is a 15th century major Indian classical dance form and one among the eight Indian classical dance forms. For this dance form, to the best of our knowledge, neither a standard dataset nor a good recognition method has been made available. Since, hand gestures are first and the foremost step for learning because of its flexibility and utility, this dataset mainly focus on single-hand gestures of Sattriya dance. The primary objective of this chapter is to develop an unbiased dataset of Asamyukta hastas of Sattriya dance and make it publicly available for performance evaluation of classifiers. Moreover, this dataset will also be relevant to other classical dances because several hand gestures of Sattriya dance, included in this dataset, are similar to hand gestures of other Indian classical dance forms with minor variation.

3.2 Related Datasets

Six different hand gestures datasets have been found in the literature. Most of these datasets either have no accessible images or contain very less number of images. These datasets are listed in Table 3.1 and described in the remaining part of the section. In addition to these datasets, there are a few other datasets which are not publicly available.

3.2.1 Hand Posture and Gesture Datasets

The hand posture and gestures dataset is available in four versions and introduced during 1996, 1999, 2000 and 2001. Out of these versions, two of them are for static hand postures [78] [39] and other two are dynamic hand postures databases [40] [79]. They use combination of different feature types and an Elastic Graph Matching algorithm were used for the recognition purpose.

Table 3.1: List of Related Hand Gesture Dataset

Dataset Name	Year	Url
Hand Posture and Gesture Datasets	1996, 1999-2001	http://www.idiap.ch/resource/gestures/
Australian Sign Language Data Set	2002	https://archive.ics.uci.edu/ml/datasets/ Australian+Sign+Language+signs
Two-Handed Datasets	2005	http://www.idiap.ch/resource/twohanded
The NUS hand posture datasets I,II	2010	https://www.ece.nus.edu.sg/stfpage/ elepv/NUS-HandSet
American sign language dataset	2011	http://iims.massey.ac.nz/research/letters
Polish Sign Language('P') and American Sign Language ('A')	2012, 2013	http://sun.aei.polsl.pl/mkawulok/gestures

3.2.2 Australian Sign Language Data Set

The Australian Sign Language (Auslan) dataset consists of 6650 samples of 95 Auslan signs. These samples were collected from five different signers. The data were collected using a Nintendo PowerGlove attached to a Silicon Graphics 4D/35G workstation connected though a PowerGlove Serial Interface. This dataset is available at UCIML repository [28]

3.2.3 Two-Handed Datasets

The two-handed dataset comprises of seven two-handed gestures collected from seven different persons. These gestures consists of six rotation gestures in all six directions (left, right, forward, backward, upward and downward) and one push gesture. The gestures were collected in two sessions and five records for each gesture. Gestures of four persons were used for training and remaining gestures of three persons are used for testing [27].

3.2.4 The NUS Hand Posture Datasets (I & II)

These datasets are available in two versions: Dataset I and Dataset II. Both the Datasets consist of 10 classes of postures each. Dataset I has 24 samples per class [35] and dataset II [55] has 5 samples per class. The images were captured by varying position and size within the image frame and consists of both gray scale and color images. The postures are captured against natural complex backgrounds in National University of Singapore (NUS) and nearby places. The postures were performed by 40 subjects including both males and females in the range of 22-56 years

3.2.5 American Sign Language Dataset

The American sign language (ASL) dataset [3] is a 2D static hand gestures color image dataset. This dataset contains 2425 images from 5 individuals, with variations in lighting conditions. The hand postures are generated with the aid of image processing techniques.

3.2.6 Polish Sign Language('P') and American Sign Language ('A')

This dataset consists of Polish Sign Language [31] and American Sign Language [50] gestures. The letters 'P' and 'A' in gestures ID indicate Polish Sign Language and American Sign Language respectively. In addition to gestures of these two sign languages, the dataset includes some special signs ('S' in gestures ID). The dataset is available in three series termed as HGR1, HGR2A and HGR2B which include three subsequent data: original RGB images, ground truth binary skin presence masks and hand feature points location.

3.3 Our Single-Hand Gestures Dataset

There are seventy six single-hand gestures (hastas) used in Sattriya dance [7]. These hastas are grouped into three categories known as asamyukta(single-hand gesture) hasta, samyukta hasta(double hand gesture) and nritya hasta. Nritya hastas are also double hand gestures which have no specific pattern and they

vary from dance to dance. However, samyukta hastas and nritya hastas both are derived from asamyukta hasta. Therefore, asamyukta hastas are basis of all hastas. This dataset is based on asamyukta hastas only.

3.3.1   About Sattriya Dance

Sattriya nritya (dance) is a major Indian classical dance form having its origin in the Krishna-centered Vaishnavism monasteries, called Satras, of the Indian state of Assam. Though, it was originated in the 15th century by the medieval polymath Srimanta Sankardev, it got official recognition as a classical dance form only in the year 2000 by Sangeet Natak Akademi of India. The core of Sattriya nritya was mythological stories and act of drama. However, with the growth of this tradition, it expresses in dance form. Now this nritya is not confined in the Sattras only and it has achieved a wide range of recognition throughout the world.

3.3.2   Data Labels

Hastas are defined as the combination of hand gestures by which viewer can understand the sequence of dances. The twenty-nine Asamyukta hastas of Sattriya dance are performed as described and approved by several famous Granthas (Epic) of Indian classical dance form viz., Natya Sastra, Abhinya Darpan (the Mirror of the gestures), Sangeet Ratnakar and Srihasta Muktaboli are as follows:

- 20 hastas namely Pataka, Padmokosha, Mustika, Hangshamukha (Hangsasya), Alpadma, Tripataka, Karatarimukha, Ardhachandra, Sarpashira, Sandangsha, Suchimukha, Urnanava, Mukula, Chatura, Tamrachuda, Kopittha, Bhramara, Khatkhamukha, Sashak (Mrigasirsha) are similar in all of these Granthas [19].

- 3 hastas namely Ardhasuchi, Singhamukha, Trishula are from Abhinaya Darpan [7].

- 4 hastas Ankusha, Tantrimukha, Granika, Krishnasarmukha from Sri-hasta Muktaboli.

- 2 hastas Dhanu and Ban are from Kalikapuran and Abhinaya Darpana.
  The twenty-nine Asamyukta hastas of Sattriya dance is shown in Figure 3-1 The hasta names and corresponding serial numeric label are given in Table 3.2

Figure 3-1: Asamyukta Hastas

Table 3.2: Numeric Label of Sattriya Dance Asamyukta Hastas

Numeric Label	Class Name
1	Alpadma
2	Ankusha
3	Ardhachandra
4	Ardhasuchi
5	Ban
6	Bhromora
7	Chatura
8	Dhanu
9	Granika
10	Hangsamukha
11	Kartarimukha
12	Kopittha
13	Krishnamukha
14	khatkhamukha
15	Mukula

Sl No	Class name
16	Mustika
17	Padmokosha
18	Pataka
19	Sandangsha
20	Sarpasira
21	Sasaka
22	Sikhara
23	Singhamukha
24	Suchimukha
25	Tamrachura
26	Tantrimukha
27	Tripataka
28	Trishula
29	Urnanava

3.3.3   Testbed Setup

The images were acquired form 6 volunteer dancers in standard Sattriya dance attire using a 13 megapixel digital camera against uniform background. The images were captured with different viewing angle of the camera and simulating a natural environment. The dancers were wearing a wrist band of colour similar to the background colour to make the segmentation of the hand from the body easy. Once the hands are segmented, they can be used for feature extraction directly.

3.3.4   Framework

The overall process for creation of single-hand gestures dataset of Sattriya dance is shown in Figure 3-2. Each of the steps are described below.
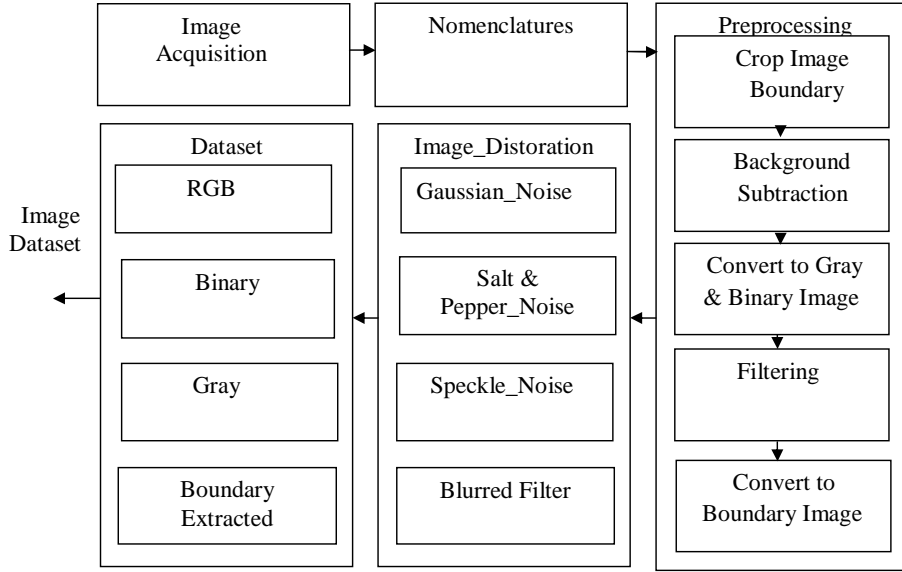
3.3.5   Major Steps

There are four major steps involved in creation of this dataset. Each of them are explained in the following subsections

3.3.5.1   Data Acquisition:

Data acquisition refers to the collection of asamyukta hand gestures from different dancers. To create this dataset, 1450 images of twenty-nine single-

Figure 3-2: Framework for Dataset Creation

hand gestures (Asamyukta hasta) from six volunteer dancers are collected. The images are captured using a digital camera. Out of the six dancers, four dancers contributed 10 images for each hasta and remaining two dancers contributed 5 images for each hasta comprising a total of 1450 images (4 dancers × 29 hastas × 10 images per hasta per dancer + 2 dancers × 29 hastas × 5 images per hasta per dancer). The images are captured using a uniform background and with a fixed distance between the camera and dancers. Each hasta has 50 images with different angle of view of the camera as shown Figure 3-3. The images were collected from three different Satras viz., Nikamul, Kamalabari and Auniati. The volunteer dancers belonging to different age groups in range from 16-26 years were reported.
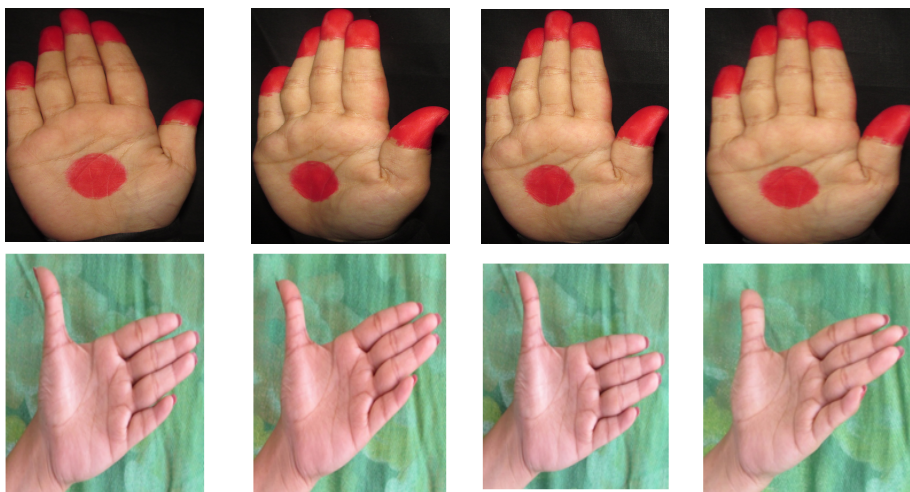
Figure 3-3: Example of Hasta Images with Different Angle of View of the Camera
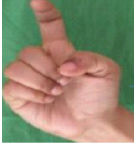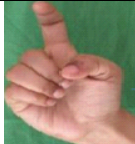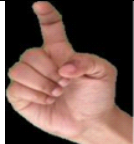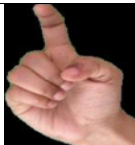
3.3.5.2   Nomenclature
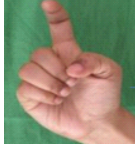
The naming of each file in the dataset follows a simple convention. The file names are in the format $Pn\_N\_T\_R$. jpg where the meaning of different parts are as follows:

- Pn : Dancer ID (n=1,2,... 6)
- N : Name of the hasta like pataka, padmokosha, ...
- T : Time of image capture on day or night, for day=d and night= n
- R : Repetition ranging from 1,2,:.10.
- Jpg : Image format.

Example : P1_ Alpadma_d_1.jpg is the file name of instance 1 'Alpadma' hasta taken from dancer 1 during day time.

3.3.5.3   Preprocessing

The prepocessing phase plays a vital role in creation of a dataset. The tasks performed in the preprocessing phase are shown in Figure 3-4 and are briefly described below

Figure 3-4: Preprocessing Steps of Hand Gesture

D.1.   Cropping   In the first step of preprocessing, the acquired images were cropped at the boundary of the hand gestures. The cropped images are resized to 200 × 200 pixels.

D.2. Background Subtraction Background subtraction of collected images had done using Gaussian Mixture Model (GMM) [47].

D.3.i. Color Image to Gray Image Conversion The cropped background subtracted RGB images are converted to gray images using the Matlab function 'rgb2gray'.

D.3.ii. Gray to Binary Conversion The gray images are converted to binary using threshold value determined by multiplying 1.6 with automatic gray threshold value of the Matlab function rgb2gray. In these binary images, object pixels are represented by '1' and others by 0.

D.4. Noise Removal Residual noise from binary images were removed by applying 25× 25 standard Gaussian filter with standard deviation (σ) value 15. The value of sigma is choosen experimentally by observing the output visually. Also you should mention the value of mean of the filter.

D.5. Boundary Extraction From the binary images the boundary images are extracted by using the matlab function *bwboundaries* (binary-image) to find out the global features.

3.3.6 Image Distortion

Additional instances of the hasta images of the dataset are generated by image distortion methods. The image distortion methods used are addition of noise and blurring. Image noise is the random variation of brightness or color information. Here, for each original image, 30 instances of images are created by adding noise. With these addition of instances, the number of hasta image in the dataset become 44,950 (43,500 noise images+1450 original images) images. The different types of noises used in this chapter are described briefly as follows [57]

1. Gaussian Noise (Amplifier Noise): This type of noise is a statistical noise which have a probability density function (PDF) with normal distribution, known as the Gaussian distribution. If PDF P of Gaussian random variable z, is given by: $P(z) = \frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{(z-\mu)^2}{2\sigma^2}}$ where μ is the mean value and σ denotes the standard deviation. For each standard image, 8 variations of Gaussian noise images with different sigma values

are created. Some images with Gaussian noise are shown in Figure 3-5
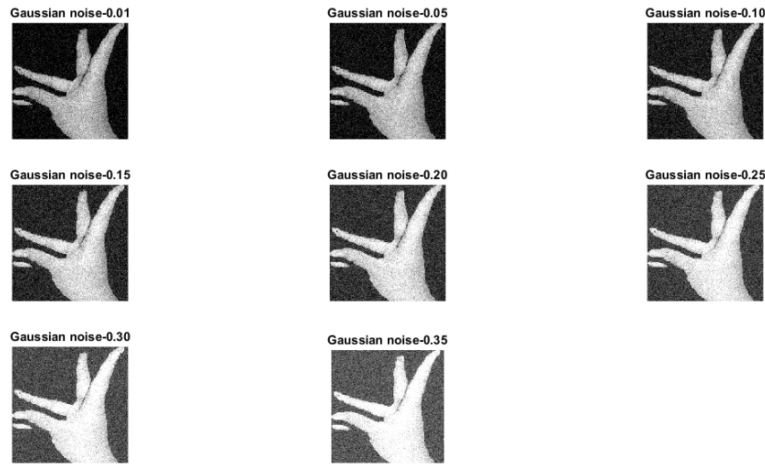
Figure 3-5: Images with Gaussian Noise

2. Salt & Pepper Noise: This noise is also known as impulse noise. This type of noise occurs as the dark pixel in bright region and bright pixel in dark region. Generally, it is caused by sudden disturbances in the image signal such as dead pixel, analog to digital converter error or bit error in transmission. The Matlab function $imnoise(I,'salt\ pepper',d)$ is used where I is the image, and d is the noise density i.e., the percentage of the image area containing noise values. The values of the density parameter are taken as 0.01, 0.05, 0.10, 0.15, 0.20, 0.25, 0.30 and 0.35. The default density of salt and pepper noise is 0.05. Some images with Salt & Pepper noise are shown in Figure 3-6

3. Speckle Noise: Speckle noise is the granular noise caused by elementary scatters. It is multiplicative noise added to the image. For each image, 4 images with speckle noise are generated with variance as 0.04, 0.14, 0.24 and 0.34 speckle noise are added. Here, only four variance speckle noise are added, because higher variance are almost similar. The default value of variance is 0.04. Images with Speckle noise are shown in Figure 3-7.

4. Blurred Images: It is a procedure to fade the images using filtering method. The images are blurred using two steps: first, the linear motion of the camera is approximated with the matlab function $psf = fspecial('motion', len, \theta)$. Here, len is the linear motion of camera by len pixels with an angle of θ degree in a counter-clockwise direction. The default len value is 9. Next, the image is blurred using the
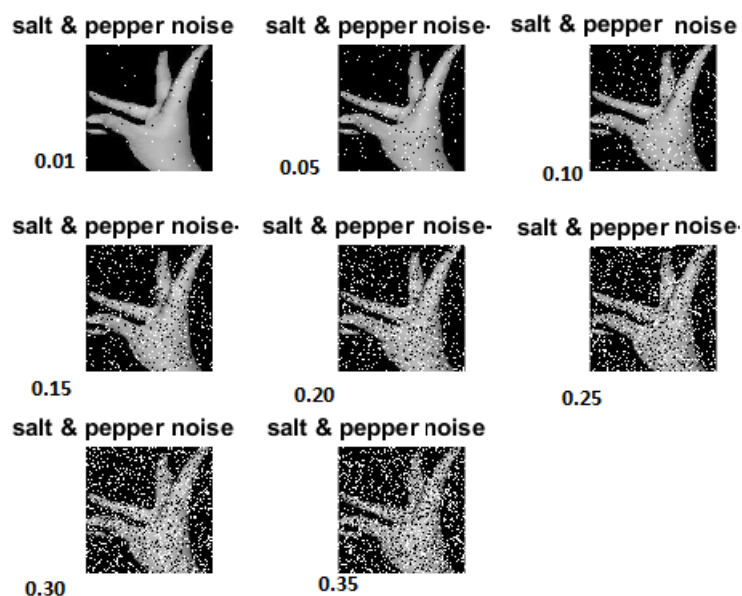
Figure 3-6: Images with Salt & Pepper Noise
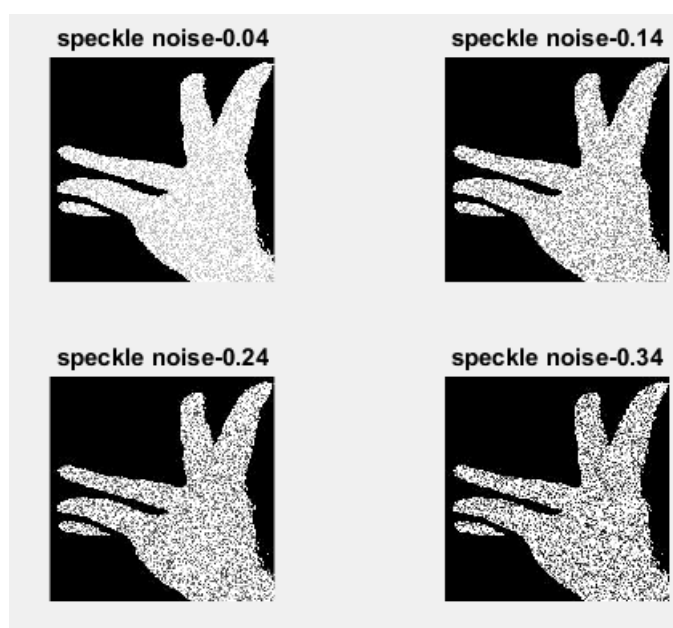
Figure 3-7: Images with Speckle Noise

matlab function *imfilter(I, psf,'conv','circular')* where I is the image and psf is the two dimensional filter return by fspecial function. The blurred images with theta values $\theta =$1, 5, 10, 15, 20 and 26 are shown in the Figure 3-8 below .

Figure 3-8: Blurred Images with Different Theta Values

3.4   Dataset Annotation

In hastas, the fingers play a very important role to express the meaning. A hasta image showing the different fingers is shown in Figure 3-9 Annotated

Figure 3-9: Finger Identification

details of the hastas in lexicographic order are provided in Table 3.3:

Table 3.3: Dataset Description

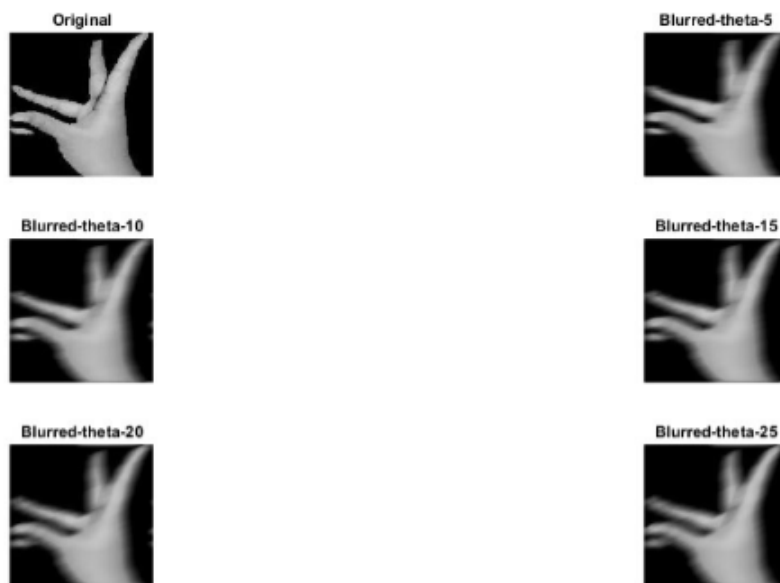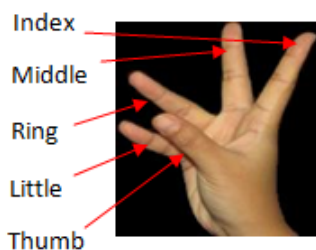| Hasta Name	Meaning	Viniyog (uses)	Techniques
Alpadma	Fully opened lotus	A fully bloomed lotus, to show fruits such as apple, circular movement, bosom, a full moon, hair knot, show beauty, separation from dear one, a mirror, a village, cakravaka bird, high altitudes.	The palm turn to face upward and stretch all fingers keeping separated and extended. And, the little finger turns toward palm and fan out the rest of the fingers evenly away from the little finger.
Ankusha	God, Inspiration	Fishhook, hook, fraud-talk, It has a great importance in the rhythmic, non-story telling dance.	The finger tip of the index finger of the hasta is slightly bent.
Ardhachandra	Crescent Moon	Half moon, sankho, to see something, new moon, grazing waist, greeting by the common people.	The thumb is bent to outside, the rest of the fingers bring together and the shape must be seen like a bow.
Ardhasuchi	Half needle	Denoting hundred, to say like that, solitude, threatening, pointing to distant place, life, walking in front, lotus stalk, sunrise and sunset, arrow, handle, listening, yearning for the beloved, recollection, nose, beak, and vision.	The index finger stretched up keeping the rest of the fingers collected under the tip of the thumb.
Ban	Arrow	Used to represent the act of putting the arrow in a bow.	All are tightly closed, only little finger is stretched out
			Continued on next page

Table 3.3 – continued from previous page

Hasta Name	Meaning	Viniyog (uses)	Techniques
Bhramora	Bee	A bee, a parrot, a wing, a heron, cuckoo, some other birds.	The middle finger is pressed by the thumb and the little finger be curled and placed.
Chatura	Clever and Witty	Water, grief, four digits, graveyard	The four fingers are spread out and the thumb is kept within the palm.
Dhanu	Arrow	Arrow, traditional plough, teeth of wild pigs (Varaha), One of the 10 reincarnations God called Haliram	The thumb of the Mustika hasta is lifted up and little finger become straight
Ghronika	Mouth of pig	Pigs mouth, water bubbles, monkey, varaha incarnation of God	All fingertips touch each other and pointed to the downward.
Hangsamukha	Swan's bill	An auspicious occasion or festival, tying thread, ascertaining the imparted instructions, horripilation (Romancha), pearl, light a lamp, a touchstone (stone meant to test gold), flowers like jasmine, to draw picture, impeding the current of water.	The thumb and the index finger touch each other at the tips, while the other fingers are straight, separated and stretched.
Kartarimukha	Arrow shaft face	Separation, corner of an eye, lightning, disagreement, to fall down, a creeper.	The little finger and ring finger are bent and pressed by thumb while the index and the middle finger are stretched to show a scissor.
			Continued on next page

Table 3.3 – continued from previous page

Hasta Name	Meaning	Viniyog (uses)	Techniques
Kopitha	Posing to goddess of wealth wood apple	Holding, cymbals, goddess lakshmi, true, false.	The little, ring and middle fingers are curled into palm, the thumb is stretched by the side of the palm, and capped it with the pad of the index finger directly above the tip of the thumb.
Krishnasar mukha	Face of krishnasar deer (Blackbuck), a species found in India, Nepal and Pakistan	Used to mean river bank, peak, deer, hare, dog, fox etc.	The hand hold raised, the little finger and index finger are stretched upward and bending. Then applying the tips of the middle and ring fingers to meet with the thumb.
Khatkhamukha	Face of crab or scorpion	Used to mean wearing ornaments, bone, bow, dambaru (a small two-headed drum, used in Hinduism and Tibetan Buddhism, Damaru in Sankskrit), etc.	The thumb brings together with index and middle fingers, keeping all the fingers become stretched and active. The ring and little fingers are facing toward upward direction.
Mukula	Flower Bud	A lily flower, eating, manmatha with his arrows. (God of love or the churner of hearts), holding the Signet, navel, flower or a bud.	The five finger are brought together and touch each other at the tip and facing towards upward direction.

Table 3.3 – continued from previous page

Hasta Name	Meaning	Viniyog (uses)	Techniques
Mustika	Fist	Steadiness, courage, holding things, fighting mood of wrestlers.	The four fingers are bent into the palm, and the thumb wraps on top of them in to a fist.
Padmokosha	Lotus bud	Various fruit, food, flower garland, cluster of flowers, hibiscus flower, lotus.	Place the palm face up and slightly bend all five fingers as draw them toward each other, keeping them separated and the palm hollow.
Pataka	Flag	Represent the wind, the abode of the gods, a year, a river and various other actions and objects.	All the fingers are extended, keeping them close to one another with the thumb bend.
Sandangsha	Pincer	Making a garland, picking up flowers, picking up blades of grass, leaves, hairs or threads, holding or pulling out an arrow, removing a thorn; painting eyes, writing a letter.	The index and thumb fingers touch each other and others three fingers closed and straight.
Sarpashira	Serpent head	Sandal paste, snake, low pitch, sprinkling, nourishing, offering water to God, flapping of elephant ears, wrestlers arms.	All the fingers together and palm facing forward, and fingers are slightly bend, rounding them in and cupping the hand to form the shape of a snake hood.
			Continued on next page

Table 3.3 – continued from previous page

Hasta Name	Meaning	Viniyog (uses)	Techniques
Sashaka	Deer	Used to mean Krishna, Brahma, seat, incarnation (avatar) etc	The middle finger and forefinger are pressed against the thumb, while the index and little fingers are straight.
Sikhara	Spire	Bow, pillar, certainty, offering to ancestors, lips, to pour liquid, Shiva Lingam or phallic symbol.	The thumb of the Mushti hasta is lifted up.
Singhamukha	Lion's Face	Primarily used by performing artists to create context and express emotional states or specific actions. Used as coral, pearl, fragrance, hearing, stroking hair, hearing, water drop, salvation, fire ritual, Rabbit, elephant, waving kusha grass, lotus garland, lions face.	The middle finger and the ring finger are bent towards the thumb, while the other fingers are held straight.
Suchimukha	Needle	Used to mean small amount, destroy, hell, etc.	The Middle finger and thumb tips meet each other, while the index, forefinger and little fingers are straight.
			Continued on next page

Table 3.3 – continued from previous page

Hasta Name	Meaning	Viniyog (uses)	Techniques
Tamrachura	Cock's Comb	A rooster, cock, a birds head, a heron, crane, a crow, a camel, a calf, a pen that is used to engrave, to reproach, to strike, to beat time, to demonstrate self-confidence, rapidity and thus to indicate any kind of gesticulation.	The middle finger crosses with the thumb, the index finger is kept bent and the remaining two fingers are pressed against the palm.
Tantrimukha	Veena	Used to mean Veena (an ancient multistringed musical instrument of Indian subcontinent), knowledge, Saraswati (Indian Goddess of Knowledge), horizontal forehead lines or worry lines etc.	The middle finger and the ring finger is bend towards the palm while other three fingers are stretched and held straight.
Tripataka	Flag in three parts	Crown, holy tree with branches, vajrayudha, raising flames, lamb, arrow etc.	From pataka, the ring finger bend into horizontal position at the lower joint.
Trishula	Trident	A holy trinity (Brahma, Vishnu , Mahesh), an idea of three, bilva leaves (A holy leaf used to worship lord Shiva).	The thumb and the little fingers are bent and the little finger pressed by the thumb, while the index, middle and the ring finger are held straight.
Urnanava	Spider	Scratching the head, receiving stolen property, leprosy, lions, tigers, holding a stone.	The fingers in the Padmakosha hasta are bent harder.

3.5 Conclusion and Future Remarks

This chapter presents a novel dataset for single-hand gestures of the Sattriya dance. The dataset consists of RGB, grey-scale, binary and boundary images and will be useful for researchers working with hand gestures in dance and beyond. The dataset includes 1450 original instances of 29 hastas. The number of instances were increased using different image distortion methods. For each original image, 30 instances are created and the dataset includes total 44,950 (43,500 noisy images+1450 original images) images. The effectiveness of the dataset is established using different classifiers in terms of classification accuracy and are discussed in the next chapters.

3.6 Acknowledgement