Chapter 2

Literature Survey

Research on dance gestures recognition has been receiving an increasing attention day by day. Gestures are powerful and natural ways of non-verbal communications in which visible body actions are used to communicate important messages [44]. The expressions of human body are roughly classified into three types of gestures [44]: (a) Hand gestures, (b) Head and face gestures and (c) Body gestures. Gesture recognition means the identification of meaningful expressions of human motion; including recognition of fingers, arms, hands, head and body expressions [44]. Gesture recognition is a multi-disciplinary research area. The application areas of gestures recognition spread from our daily life activities to Artificial Intelligence through Electronics Engineering [76], Medical Science, Education and Robotics [15] and also for entertainment [16] purpose.
In the recent past, several reviews on gesture recognition [44], skeleton gesture recognition [37], vision-based gesture recognition [45] and vision-based motion capture [45] have been published in literature. Various issues and challenges in this research domain are highlighted in this survey which is not found in most of the surveys reported in the literature. A taxonomy of gestures and classification techniques are also provided. Additionally, a comparison of various glove based and vision-based techniques is also presented.

The aim of this survey is to present a comprehensive literature review on automated dance gesture recognition with emphasis on static hand gesture recognition. Out of the three classes of gestures, hand gestures are considered in the work because human hands are the most flexible parts of the body and play most significant role in conveying messages. Culture specific hand gestures convey different messages in different culture. However, the main aspects of this survey is to provide a taxonomy of gestures, existing works on automated gesture recognition in dance domain in order to appreciate the work presented in this dissertation.

2.1 Applications of Gestures Recognition

Automated gesture recognition has a wide range of applications. In this section six major applications are presented.

2.1.1 Computer Vision

Gesture recognition in computer vision helps in improving Human Computer Interaction (HCI). For example, it provides support to young children or physically challenged people to interact more effectively with computers. Development of various sign languages like American sign language [74], Arabic sign language(ArSL) [38], Japanese sign language (JSL) [49, 75], Korean sign language(KSL) [10, 34], Brazilian sign language(BSL) [4] gives new life for hearing impaired and physically challenged people. System developed for hand gesture recognition in computer vision can easily recognize the gestures and use them for controlling the electronic devices [82]. An example of vision-based hand gesture used in this systen is given in Table 2.2

Table 2.1: Example of Vision-Based Hand Gestures for Controlling Electronic Devices

Sl. No.	Hand Gestures	Meaning
1	Horizontal right hand moved in upward direction	Channel Up
2	Horizontal right hand moved in downward direction	Channel Down
3	Horizontal left hand moved in upward direction	Volume Up
4	Horizontal left hand moved in downward direction	Volume Down
5	Vertical hand (left/right) closed Mute/Unmute	Volume Down
6	Horizontal hand (left/right) moved towards the sensor	OFF

2.1.2 Electronics Interface

The demand for touch and touchless technologies are another major scope for gesture recognition applications. The remote control device, multi-touch device, touch pad, smartphones, input devices like wired gloves, depth-aware cameras, stereo cameras all are directly or indirectly involved with gesture recognition research.

2.1.3 Artificial Intelligence

Gesture recognition mostly focused with the analysis of functionality of human being. It aims to gather and represent human gestures and use them to convey meaning. Recognition of sign languages and lie detection are other possibilities of gesture recognition [44].

2.1.4 Neurology

The main task of neurology is to develop and support human intelligence. Understanding human emotion and behavior is the most important research area in present day world. Gestures are generally processed in the left inferior frontal gyrus (Brocas area) and the posterior middle temporal gyrus area. These areas of the brain support the pairing of gesture and meaning and it adapts in human evolution. It works for both co-speech and speechless gestures [8].

2.1.5 Medical Science

Monitoring the patients emotional state and stress is another major application of gesture recognition. Hand gesture recognition systems can help doctors in surgical environment to manipulate digital images during medical treatment [8].

2.1.6 Social Significance

Today, gesture recognition also has an important role in our daily life from official works to entertainment activities. An important contribution of gesture recognition is e-learning. It makes easy to communicate in video conferencing. Gesture can work as a bridge between human and computer i.e., human-computer interaction (HCI) which makes it more user-friendly and more flexible [15].

The rest of this chapter is organized as follows. Section 2.2 discusses about the taxonomy of gestures recognition. Section 2.3 provides the generic view of dance gesture recognition which is the prime focus of this work. Section 2.4 covers the work review on dance gesture recognition domain followed by study on glove-based as well as vision-based approaches. Section 2.5 concludes this chapter.

2.2 Gestures Taxonomy

Gestures are broadly classified into two types: static gestures and dynamic gestures as shown in [44]. Apart from this broad classification, several other classifications

Table 2.2: Basic Types of Gestures

Gestures	Meaning	Example
Static gestures	Static gestures are those where the user assumes certain pose or configuration [44]. In this gestures the angle between the fingers become fixed [62].	
Dynamic gestures	Dynamic gestures are those gestures where angle between the fingers change with respect to time [62]. In this gestures three phases pre-stroke, stroke and post stroke are considered	

are provided by various authors. Some of these classifications are depicted in Figure 2-1 and described in the remaining part of this section. Gestures have variously been classified by different people [41, 80] in different period of time.

2.2.1 Efron's Classification

Efron is considered to be the pioneer of classifying gestures. His classification is based on the linguistic aspects of gesture behavior and expression [80]. According to him, gestures can be of two types: objective gestures which are speechless and logical discursive that describes along with speech. Objective gestures are farther categorized into three types of gestures viz., deictic, physiographic and

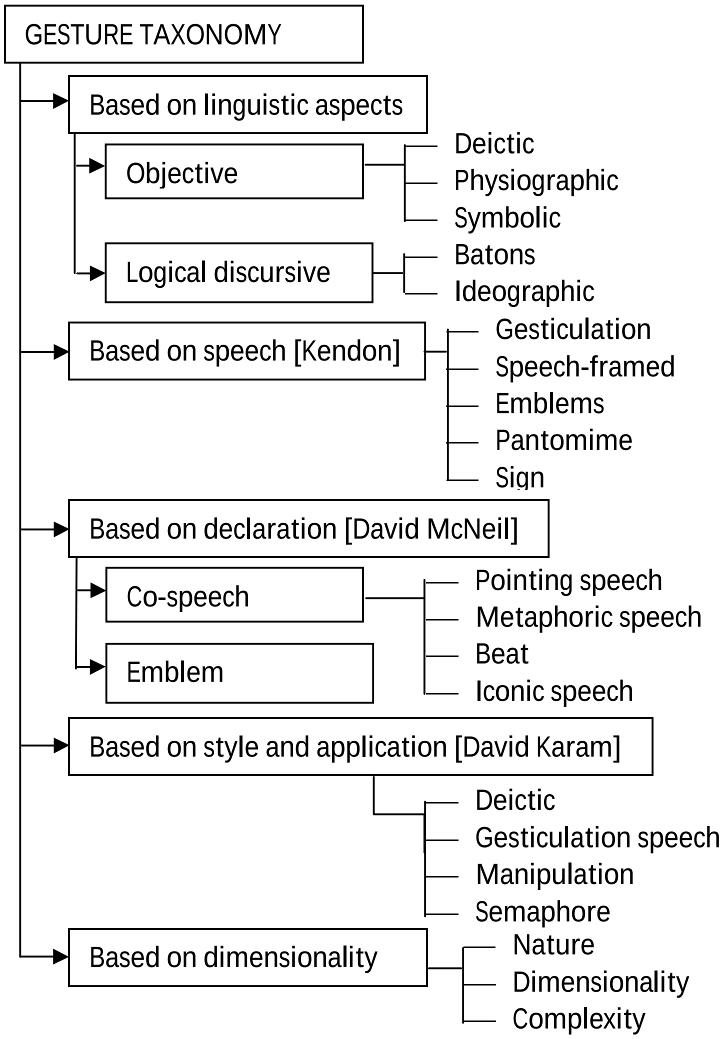

Figure 2-1: Gesture Classification: A Taxonomy

symbolic gestures. Logical discursive gestures are sub classified into batons gestures and ideographic gestures. The details of Efron's sub-clssification is defined in Table 2.3 [80].

Table 2.3: Effron's Classification

Gestures Classification	Types	Sub classification	Significance
Objective	Speechless	Deictic	Identify objects by pointing
		Physiographic	These gestures are found in the form of a visual objects/ iconographic gesture/ bodily action
		Symbolic	This gesture uses from known vocabulary. It has different meaning in different country.
Logical Discursive	Along with speech	Batons	These are rhythmic gestures.
		Ideographic	This gives idea using gestures.

2.2.2 Kendon Classification

In the year 1988, Kendon classified the gestures based on the variety of requirement and speech dependency [80]. These gestures are classified into five types as [42].

1. Gesticulation gestures: This type of gestures are used in general conversation with utterance. Example: head nodding and shaking
2. Speech-framed gestures: These gestures are the part of the sentence itself. Example: Sylvester went [gesture of an object flying out laterally]
3. Emblems gestures: These gestures are recognized in absence of speech. Example: The ring (first finger and thumb tips touching, other fingers extended) for OK
4. Pantomime gestures: These gestures are used to narrate the story in absence of speech.
5. Signs gestures: They are mostly used in sign languages. This type of gestures have their own linguistic structures, grammatical patterns, vocabulary and morphological patterns.

2.2.3 David McNeil Classification

According to David McNeil, gestures are classified into co-speech gestures and emblems gestures [41].

2.2.3.1 Co-speech gestures

Co-speech gestures are the type of gestures which are used along with word. These types of gestures are categorized into the following types:
i) Iconic: These gestures are used along with speech. Whenever we express some physical matter we use our hands to explain it more clearly. For example, if we describe about some real item like how big or small it is, then we paint our hand along with the word. Iconic gestures are different from the rest of gestures in the sense that it is used to describe real and existing matter.
ii) Pointing: The pointing gestures refer to the way people show the knowledge by pointing. One can indicate a place or perhaps a thing moving from one place to another using this gesture. For example, if we point someone across the room, then, naturally we make point our finger in the appropriate direction.
iii) Metaphoric: This type of gestures can express an idea in a general way. For example, when we are describing something complex, we wave our hand in the air. This kind of gestures also add emotion and spice to the accompanying speech. Sometime it is more or less dramatic. Making our hands into heart shape and placing in our chest to show the affection to a loved one.
iv) Beat gestures: Beat gestures are related to rhythmic beating of hand expressions. Sometime they may be described by a single beat or may continue the whole duration as long as explaining some particular point. These gestures can vary depending on situation [41].

2.2.3.2 Emblems gestures

Emblem gestures are independent of speech. They are specific type of gestures with specific meaning that are intentionally used and unintentionally understood. These gestures are used as a substitute of words which are similar to sign language. For example we can recognize different alphabet and numbers by using our hand expressions.

2.2.4 David Karam's Classification

Karams classification of gestures are based on representation of gesture, application domain and input output technology [80]. These gestures are of four types: deictic, semaphores, gesticulation and manipulation.

1. Deictic: Deictic gestures refer to pointing to identity or spatial location of an object.
2. Semaphore: This kind of gestures can be expressed via body part or other objects and electronic devices, such as a mouse.
3. Gesticulation: Gesticulations gestures are co-speech multimodal gestures, consisting of hand movement. This kind of gestures are not pre-planned.
4. Manipulation: This kind of gestures are also referred to as physical gestures. This class of gestures gives importance to the relation between hand movement and the object being manipulated.

2.2.5 Ruiz Classification for 3D Motion Gestures

This classifications of gestures is used in 3D-motion gestures that are applied on mobile device (smart phone). The gestures are classified based on physical characteristics [80]. The physical characters are kinetic impulse, dimensionality and complexity. These gestures are categorized as body part, handedness, hand shape and the range of motion. The four types of dimensionality used for the gestures are used as

1. Single-axis: These gestures are used around the single axis.
2. Double-axis: These gestures are used on plane i.e., on 2D surface area.
3. Tri-axis: These gestures are used in 3D space and works either on translational motion or rotational motion.
4. Six-axis: These gestures are also used in 3D space but difference is the it works on both types of motion, translational as well as rotational motion. The Complexity of these types of gesture may be of simple or complex, depending on the situation

2.3 Dance Gestures Recognition Framework

Automated dance gesture recognition is a special task of general gesture recognition. Dance gesture recognition means the recognition of meaningful expression from different dance images (poses). Automated recognition of dance gestures can help in creating universal communication environment for a dance drama, independent of the language used in the associated song [46]. Therefore, such recognition system helps a viewer to understand the meaning of dance sequences irrespective of the language of the background song. Also, it includes applications such as dance self-assessment and e-learning of dances [19, 22].
The procedure for dance gesture recognition can be divided into four major phases as shown Figure 2-2; viz., (a) image acquisition (b) preprocessing, which can be further divided into two major tasks, i.e., (i) segmentation and (ii) boundary detection, (c) feature extraction and (d) classification and recognition. We now describe each of these phases, in brief.

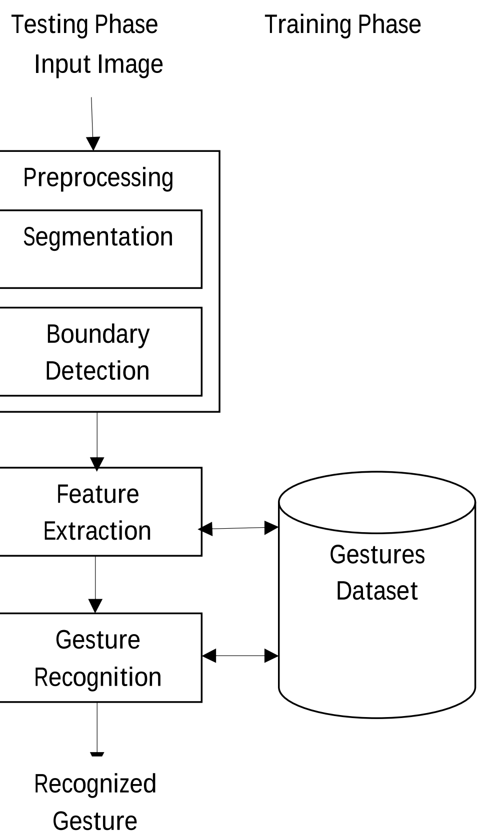

Figure 2-2: Generic View of Dance Gesture Recognition System

2.3.1 Image Acquisition

The capturing of image is generally performed by a cleaned environment with uniform background using single camera. If we use two cameras with approximately orthogonal direction then we can easily reduce the ambiguities compared to single view approach. Kinect sensor camera [67] or depth sensor camera [22] are used for capturing 3-D images. The images can be directly skeletonized and also the position of the skeleton can be estimated by using both of these cameras.

2.3.2 Preprocessing

The main task of this phase is to process the images captured in the previous phase without losing their salient features. The preprocessing of the images includes cropping, resizing, filtering, transforming (using filter like Gaussian or Gabor Wavelet) and extracting the object from the background. Preprocessing task can be broadly divided into the following two steps:

- Segmentation: Segmentation is the process by which objects of different shapes can be extracted from the background. The segmentation algorithms are dependent on different types of features. Some of them are skin color based [54], texture based [5], saliency object based. Hybrid Saliency algorithm [46] is a very popular segmentation algorithm which is used on images with complex background to highlight the object from background and to find out the salient feature of the images. Using this algorithm the salient regions can be differentiated from the background details easily.

- Boundary Detection: Most of the time image segmentation algorithm do not give a clear boundary of the object. Many morphological operations are used to resolve this problem. The general morphological operations are used for boundary detection are erosion, dilation, thinning, filtering and hole filling operations. For example, skin color-based segmentation algorithm contains many irregularities [19]. Using opening operations (erosion preceded dilation operation) [63], it is possible to remove these irregularities. The chain code generation algorithm is used for detecting the unbounded edges [63]. Resultant boundary of texture-based segmentation contains topological error like hole. To fillup these holes different filling operations, Sobel edge detection and many others techniques are used.

2.3.3 Feature Selection and Extraction

After preprocessing, the next step is feature selection and extraction. It is a process by which we can transform the input data into a set of features. The selection of feature(s) is not an easy task. It is very important to choose proper feature(s) to classify the images. Orientation histogram [19, 65], hybrid saliency techniques [46], steer filter [19] are some existing feature extraction techniques used to extract features like area, major axis length, minor axis length, centroid and eccentricity of mudra images. A major issue is to find out an optimal and relevant feature vector that can help classify the images in any complex background with high recognition accuracy.

2.3.4 Classification and Recognition

This is the final phase of gesture recognition. The goal of this phase is to classify an unknown gesture image into one of the categories or classes. The classification and recognition may be either supervised or unsupervised. In supervised approach the gesture dataset is divided into training phase and testing phase [46]. Usually, a major part of instances in the dataset are used as training set and the remaining portion are used to classify or test the data [67]. The different classification techniques [30] for dance gestures are artificial neural network(ANN), decision tree(DT), support vector machine(SVM) [68], fuzzy classifier, fuzzy set theory-based techniques [73], hidden markov model [53], back propagation neural network [20], particle filtering and graph theory-based [44], fuzzy L-membership [65] and KNN(k-nearest neighbour) [18] algorithm.

2.4 Existing Work on Dance Gestures Recognition

The dance gesture recognition research has been considered as an emerging field of research in computer science. It has gained huge attention within a short duration among the research community across the globe [19, 46, 63, 67, 68, 70]. Efron [14] was the first who worked on gesture analysis in psychology. He divided the performance of hand gestures in three phases: preparation, stroke and retraction. He showed that gestures were used as the building blocks for complex motions or phrases. Later Kendon continued Erfon's work [32] and develop how gesture

related to words in language. Since then, gesture analysis in dance field has come into being.
The available gesture recognition research on dance are mostly done on following dance form:

- Bharatnatyam [19, 46, 63, 70], where recognition based on two level decision making system and works with single hand gesture.
- Odissi [67, 68], where the gesture of whole body using kinetic sensor. Their work is carried with only eleven co-ordinates out of twenty different joints of skeleton
- Bali Traditional Dance [22], which works on probabilistic grammar-based classifier
- Ballet Dance [63] where multiple stage system is proposed to recognize the different dance posture
- Kazakh Traditional Dance [53] is basically concerned with the head gestures and many others.

One of the most important and the oldest algorithm for dance gesture segmentation is the hierarchical activity segmentation [29] algorithm. This algorithm is based on an understanding of human body instruction. It represents all the 22 physical segmentation of human anatomy and each segment has independent movement. Here, all higher level (parent) segments inherit the combined characteristics of all lower (child) level segments. The algorithm considered the variation of gestures from one choreographer to others. But this algorithm is limited to a finite set of pose states. Another popular algorithm found in this domain based on torso frame for human joint is known as Skeletal Tracking Algorithm (STA) [60]. The algorithm represents all the angular skeleton and mapping the skeleton motion data into a smaller set of features. The torso frame is computed as a basis of co-ordinate of the other skeleton joint. Research on classical dance ontology-based approach for designing a cultural heritage repository for digitizing the record of music and performance of Indian classical dance is found in [36]. Since dance and music are stored as multimedia formats so they use multimedia web ontology language (OWL) to encode the domain knowledge. They proposed an architectural framework to construct the ontology with a training data and use that for automatically annotate new instances of digital heritage artifacts. Also they develop a browsing application for semantic access of traditional collection of Indian dances. The author gives emphasis on Odissi dance. Also the Multimedia Web Ontology

Language (MOWL) has been used which is an extension of OWL language used to ensure the compatibility with W3C standards. The author collected ICD dance videos which were contributed for research. A work by a group of researchers on gesture recognition of Bharatnatyam hastas is reported in [19]. Bharatnatyam is the oldest dance form of Indian classical dance. This group developed a prototype to recognize the 28 asamyukta hastas of Bharatnatyam in two dimensional form. They work for making self-learning facilities for dancers and to promote e-learning of Bharatnatyam across the world. In [22], emphasis has been given on Bali traditional dance. The aim is to build a robust recognizer based on a method motivated by linguistic. The authors used the Alergia algorithm with Symbolic Aggregation Approximation (SAX) discretization method and achieved 92% accuracy. The work based on important joint features like left/right foot and left /right elbow of Bali traditional dance. The authors of a work reported in [68] have proposed a gesture recognition algorithm for Indian classical dance style using sensors. They made one device which generates the skeleton of human body from which twenty different junction in 3-dimensional coordinates are obtained. They use a unique system and extract the features to distinguish anger, fear, happiness, sadness and relaxation. They calculated the distance between different parts of the upper human body and generate velocity, acceleration along with the angle between different fingers. On the basis of these they extracted twenty three features. The accuracy of their method is achieved 86.8%. In [46], the authors proposed a method to recognize the mudra sequence using image processing and pattern recognition techniques and apply the result to the different expressions of classical dance. The recognition of mudra sequence can create language independent universal communication environment for the dance drama. Their system consists of two major components: training and testing. They used hybrid saliency technique in image to highlight the object from background and to find out the salient features of double hand mudra image. The author used hyper complex representations [46] for static mudra and k-nearest neighbor algorithm for classification. The features of different mudra are extracted and the values of these features are compared with the feature values for each mudra in the database. Output of this technique is emotional description for the recognized mudra images. In [53], the authors work on Kazakh traditional dance gesture recognition for detecting the head movements. The author used Microsoft kinetic sensor camera to collect human skeleton and depth information for their research. Also, they used tree structured Bayesian network and expectation maximization (EM) algorithm with K-means clustering to calculate and classifying the poses and Hidden Markov Model (HMM) is used for pose recognition. The dance gesture recognition approaches mention in the above literature review and similar other

works reported in the literature can be divided into the following two groups:
(i) Glove-based approach and
(ii) Vision-based approach. We discuss each of these approaches next.
These two approaches are discussed in more details in the next section

2.4.1 Glove-based Approach

In this approach , sensor devices and hand gloves are used in the image acquisition phase. It provides the co-ordinate points of skeleton and orientation [45]. In this approach, user can directly connect with the electronic devices. However, this approach is very expensive and inefficient for working in virtual reality. The works on dance gesture recognition in glove-based approach are summarized in Table 2.4. In glove-based approach, segmentation algorithm is not required. The sensors used in image acquisition give skeletanized images automatically.

2.4.2 Vision-based Approach

In this approach [45], the images are captured by camera. This approach is a very simple and deals with the simple image characteristics like color, texture and intensity values. However, this approach is not able to provide appropriate result in complex processing techniques which have been used to handle background, lighting variation, indistinct color combination. The works on dance gesture recognition using vision-based approach are summarized in Table 2.5

2.4.3 Methods used in Gestures Recognition System

Some commonly used tools and techniques in gesture recognition system from the areas of statistics, pattern recognition, image processing, computer vision, soft computing are described below:

A. Statistical Methods

The statistical methods are [23, 43] broadly applied for audio signal analysis, data mining, bioinformatics and many other subjects related to science and engineering branches. It covers the basic topics like dimensionality reduction, linear classification, regression as well as other modern topics such as Support Vector Machine (SVM), Hidden Markov Model (HMM), Principal Component Analysis and Linear Discriminate Analysis. This approach usually follows the supervised learning

Table 2.4: Glove-based Gesture Recognition

Dance	Features/Parameter	Classifier	Accuracy	Limitation
Oddissi [67]	Vertices of 4-side polygon, edge length angle between the different vertices.	Multi-class SVM	92.7	Dancer should stand within a range.
Oddissi [73]	A total of 23 features have been extracted based on distance, velocity, acceleration, and angle measurement.	SVM	68	Worked with only five gestures.
Bali traditional dance [22]	Skeleton features are measured by (θ, ϕ) where θ denotes inclination and ϕ denotes azimuth. Features with highest Cophenet Correlation Coefficient (CCC) values is considered.	Probabilistic grammar based classifiers	92	Tested with limited set of samples and poses.
Kazakh Traditional Dance [53]	Skeleton features extraction: inclination and azimuth angle values of particular joint vectors. Joints are-Right Hand (RH), Left Hand (LH), Right Elbow (RE), Left Elbow (LE) and Head	Bayesian network, Hidden Markov Model, EM approximation algorithm, K-means clustering	90.82	Focus only head movement.

method but sometime it may show unsupervised characteristics. In this approach, one can easily apply probability theory and decision theory. These statistical approaches crucially depend on the choice of features

B. Methods Based on Finite State Machine

A finite state machine (FSM) is a machine that makes transition with a finite number of state based on some input parameter. This machine is design for both computer program as well as sequential logic circuit. FSM can model a huge number of problems like automata, gesture recognition, networking design and artificial intelligence. The recognition of gesture can be performed using online trained FSM. When feature vectors are supplied as a input to the recognizer, if it reaches the final state then the gesture has been recognized [44].

C. Soft Computing Methods

Soft computing methods are used in the problem of computer science whose solu-

Table 2.5: Vision-based Gesture Recognition

Dance	Segmentation Techniques	Features/Parameter	Classifier	Accuracy	Limitation
Bharat Natyam [19]	1. Skin color based2. Morphological operation of thinning.	Geometric features histogram orientation, gradient at corner point of skeleton, cost function.	Two-level decision making system	No mentioned	1. Miss classification due to irregularities in skeleton structure from the hands of different people with different textural properties. 2. Generally the fingertips of the hands are coated with red dye when Bharatanatyam dance perfomed.The red tips of the fingers are erased after segmentation.
Bharat Natyam [46]	Saliency detection techniques	Area, major axis length, minor axis length and eccentricity of each mudra image.	K-nn classifier.	85.29	Miss classification chances are more.
Ballet Dance [64]	Skin color based segmentation and morphological operation are used	Distance of Straight line,Fuzzy membership values	Fuzzy T-norm	82.35	1. Skin color segmentation algorithm produce sub optimal results when dressing and skin color matched.2. Performance of the algorithm drops in case of postures containing bounded regions.
Bharat Natyam [66]	Texture based segmentation and Sobel edge detection technique	Fuzzy L Membership values, Euclidean distance	Summation of fuzzy membership value and similarity function.	85.1	Algorithm is suitable for simple background images only.

tions are not predictable, uncertain and between 0 and 1. Soft computing problems are used when we do not have enough information about the problem itself. The main tools and techniques of soft computing method are fuzzy logic (FL), neural network (NN), support vector machine(SVM), evolutional computing (EC), machine learning (ML), probabilistic reasoning (PR), genetic algorithm (GA) and rough sets. These techniques are very popular for gesture recognition domain. Generally, fuzzy set and rough sets are used to measure the uncertainty level of gesture. Other popular method like fuzzy rule based [4] and NN [25] are also used for glove based hand gesture recognition and vision based hand gesture recognition respectively.

D. Hybrid Methods

The aims of hybrid methods are to combine the advantages of different approaches within a single system. The hybrid classification methods are very useful for gesture recognition. St Jepan Rajko and Gang Qian [59] use the elements of both HMM and dynamic programming alignment (DPA) methods like edit distance, sequence alignment and dynamic time wrapping to propose a hybrid method HMM/PDA for gesture recognition. This hybrid method takes the robustness and effectiveness property of HMM and the simplicity property of DPA approaches.

Other than the above approaches, some of the most popular and frequently used models for dance gestures classification are described as follows

E. Method using Hidden Markov Model

Hidden Markov Model (HMM) is a powerful tool for dynamic gesture recognition. It is composed of number of states like finite state machine. The two basic states of HMMs are hidden state and visible state. In HMM, the states are not directly visible, but each hidden state emits one visible state and output depends on this visible state. Each hidden state randomly generates one of n observations $O_1, O_2, \ldots, O_n$.

An HMM is represented as $M = (M_1, M_2, \pi)$. where $M_1 = (m_{ij})$, $m_{ij} = P(s_i/s_j)$ denotes to specify a matrix of transition probabilities, $M_2 = (P(O_m/S_i))$ represent the matrix of observation probabilities and $\pi = (P(s_i))$ is the initial probabilities [44]. The central issue of HMM is learning. If the machine is not trained properly then the recognition results are not usually satisfactory.

F. Method using Back Propagation Neural Network

Back Propagation Neural Network (BPNN) a very simple method even for complex problems which have huge amount of parameters. Generally, Artificial Neural Network (ANN) are classified as single layer neural networks and multi layer neural networks. Back propagation neural network (BPNN) is under the category of multilayer networks. It has more than one or more hidden layers exist between the input and output units. Multilayer perception neural network is very important tool for classification purpose. Back propagation learning algorithm for static hand gesture recognition gives accuracy up to 86.38% [20]. A major advantage of this method is that it is based on learning rather than programming. So this method takes less time compared to programming method and no need to specify the exact behavior of the model. It is also very robust in nature i.e., flexible in changing environment. It takes some more time in case of drastic changes but it has good adjusting power for constantly changing environment.

2.5 Conclusion

In this chapter, a comprehensive survey on recognition of gestures, dance gestures and hand gestures is presented. The survey provides a detailed understanding of the state-of-the-art in this area. The research contributions based on this understanding are presented in the subsequent chapters.