Chapter 2

Review of Related Work

2.1 Overview

Research in human-gait analysis has now spanned six decades. Based on major advances, the work has been carried out not only by researchers from Engineering and Technology field but also from Medical sciences. Determination of behavioral traits and prosodic features (DBTPF) is one of the components of biometrical study. The main applications of such study may be found suitable for diagnosis and treatment of flat foot problem for the doctors. It may be also applied in defense during fresh recruitment. The gradual progress in the area of automatic human-gait recognition since past sixty years, have been surveyed in this chapter of the thesis and the issues for the further research in this area have been investigated.

2.2 Human-GAIT Analysis

Analysis of human walking movements, or human-gait, has been an ongoing area of research since the advent of the still camera in 1896. Since that time many researchers have investigated the dynamics of human gait in order to fully understand and describe the complicated process of upright bipedal motion. A number of areas have emerged in which considerable research has been done that exploits the analysis of this motion. These areas include clinical gait analysis, used for rehabilitation purposes, and biometric gait analysis for automatic person identification. Clinical gait analysis focuses on collection of gait data in controlled environments using motion capture systems that are intrusive. Data acquisition must be implemented in special facilities, which are used specifically for motion capture. Biometric goals of human gait analysis are much different. In that the goal is to unobtrusively observe and analyze an individual’s gait in a variety of different areas and scenarios. Various method adapted by the researchers for human-gait analysis can be categorized into Structural methods of human-gait analysis, and structure free method of human-gait analysis. Brief description of the two categories has been discussed in subsequent subsections.
### 2.2.1 Structural Method of Human-Gait Analysis

A 2D structural model of human walking has been formed. From the model different walking poses are extracted. The structural components of the human walking model has been obtained and labeled. When an unknown human-gait image has been given as input, comparison has been done best fit match between the structural components of input human-gait image and the labeled components of human walking model Hoffman D. D. et al. (1982). Then the human-gait recognition has been done by mapping the structural components of the human walking to the low-dimensional features and then the pattern classification techniques have been applied.

### 2.2.2 Structure free Method of Human-Gait Analysis

The structure free methods characterize the human walking without considering any basic structure. These methods perform the human gait recognition using a sequence of human walking poses. In some methods the recognition has been done using the static components of the human walking in the sequence of poses. In some other methods the recognition has been carried out using the spatiotemporal parameters of the sequence of human-gait poses.

### 2.2.3 Parametric Human-Gait Recognition

In parametric human-gait recognition either the shape or the motion of the body has been modeled to extract the features of human-gait mechanics such as stride dimensions and joint angles. Bobick, A. F. and Johnson, A. Y. (2001) have used a parametric gait recognition technique. They have extracted four static parameters of human-gait images namely body height, torso length, leg length and step length for person identification. BenAbdelkader, C. et al. (2002) have proposed a parametric approach by considering the parameters namely oscillations of the subject’s height and the stride dimensions.

### 2.2.4 Non-Parametric Human-Gait Recognition

In non-parametric method the human-gait recognition has been carried out by computing the features as a function of spatiotemporal characteristics of the human-gait image sequence. Then the normalized feature vectors have been extracted. The human gait recognition has been done by using the feature vectors as input to a standard pattern classification algorithm. The basic block diagram of the method has been depicted in figure 2.1.
2.3 Brief History

Gait analysis and recognition is an active interest of many computer vision research groups. Although current interest concerns computer vision, gait has been studied from several different viewpoints in the past. Those in areas of kinesiology (study of mechanics and anatomy in relation to human movement), physiotherapy, orthopedic surgery, and ergonomics (means the science related to man and his work embodying the anatomic, physiologic and mechanical principles affecting the efficient use of human energy) have all had interest in gait analysis. According to Ben-Abdelkader, C. et al. (2004) the interpretation of human gait is the synchronized, integrated movements of hundreds of muscles and joints in the body. All humans follow the same basic walking pattern, but their gaits are influence by functions of their entire musculo-skeletal structure. Limb lengths, body mass and shape, stride length, and several other factors influence how a person walks.

Applications for gait recognition seem to fall into two or three main categories. Gait recognition as a biometric, and as a tool in rehabilitation or sports activity. As a biometric gait can identify suspicious individuals or grant entry to those authorized to restricted access locations. From a rehabilitation standpoint, gait analysis can be used to identify musculo-skeletal deficiencies and develop programs for such.

Very limited research has been done in the area of gait analysis in a global sense. A system that observes and analyzes human gait for determination of abnormalities would provide a considerable amount of useful information for applications including surveillance, rehabilitation and various other unobtrusive gait analysis systems.

Although much research has been done in the field of computer vision for the analysis of human gait, very little work has been done in the area of global gait analysis for the detection of gait abnormalities like flat foot recognition. The majority of the work done in
this area utilizes motion capture data, assumes that all joint locations are marked, utilizes synthetic image data, or is very limited in scope and effectiveness in order to classify a limited number of grossly different human motions (such as various gymnastic movements).

The flexible flatfoot “may be regarded as the normal contour of a strong and stable foot, rather than the result of weakness in foot structure or weakness of the muscles which motivate the foot”, as per the discussions made through the work carried out by Harris and Beath (1948). They stated that this type of problem is of little consequence as a cause of disability. Many noted foot and ankle experts have agreed this concept. Nevertheless, controversy abounded for decades prior to these statements and has continued for nearly five decades since.

Moreover, it must be emphasized that a flatfoot is not a single deformity at a single ankle joint and at the knee joint. Flatfoot is a term used to describe a recognizable clinical deformity created by several adjacent joints in the foot.

Despite this lack of precision, it has been found from the literature that some feet have lower arches than others, which are termed as flat foot problem. Harris, R. I. et al. (1948) experimentally found flatfoot in 23 per cent of the cases out of 3619 cases. As per their work, it has been found that, the shapes of the hones and the laxity of the ligaments of the foot determine the height of the longitudinal arch. As per Mosca, V. S. (1995) muscles are important for balance. Flexible flatfoot is present from birth and is more common in children than in adults.

Many researchers from engineering field till 1970 have not carried out the work for GAIT analysis. Nashner, L. M. (1980) further continued the concepts made in previous work done by Harris and Beath (1948). He carried out the work in detecting the problems while walking for the cardiac problems. The errors have been investigated in the work done by Nashner L. M. (1980). Garrett, M. et al. (1983) carried the work for maintaining the speech of walking through Electromyography (EMG) and Gait analysis. Berger W. et al. (1984) detected angle movement and disturbances during walking. The swings between the knee angle and joint angle have been investigated through the experimental work done by Dietz V. et al. (1986). Dietz V. et al. (1987) further modified their own work for a comparative study related to transfer characteristics or responses in between the long leg and short leg problems through GAIT analysis. Yang, J. F. et al. (1990) further carried
the experimental work for the detection of short and long steps during walking. Grabiner, M. D. et al. (1993) investigated that when a obstacle is placed in the path of a subject, how much time is taken by the subject to recover its normal walking after hitting the obstacle. The same work has been carried out by Eng, J. J. et al. (1994) with little modifications and detection of angles. Schillings, A. M. et al. (1996) investigated that when an obstacle is placed in the path of subject, how much time taken by the subject to recover its normal walking without hitting the object and they have calculated the angles of movement. Tang, P. F. et al. (1998) has been carried out a work on slip simulation by using GAIT analysis. Schillings, A. M. et al. (1999) have further carried out the work done in the year 1996 with little modifications to recover normal walking of the subject. Pavol, M. J. et al. (1999) extracted some features through GAIT analysis for finding maximum likelihood of falling after making a long trip. Owings, T. M. et al. (2000) extracted some more features continuing the work done by Pavol M. J. et al. (1999). Smeesters, C. et al. (2001) calculated the trip duration and its threshold value by using GAIT analysis. Pavol, M. J. et al. (2001) have extracted some more features for speedy recovery after a trip in older adults. Smeesters, C. et al. (2001) have carried out the work for slips and sideway falls to detect the GAIT speed and detection of possible hip fractures. Pavol, M. J. et al. (2002) have carried the work done in the year 2001 by them both for older and younger subject.

Bobick, A. F. et al. (2001) has developed a gait recognition method based upon static body and stride parameters measured during walking. Ben-Abdelkader, C. et al. (2002) have proposed a parametric method to automatically identify people in low-resolution video by estimating the height and stride parameters of their gait. Kale, A. et al. (2003) have carried out work on appearance-based approach to the problem of gait recognition. In their work the width of outer contour of the binarized silhouette of a walking person is chosen as the basic image feature. Huang, P. S. et al. (1998) proposed an approach to recognize people by their gait from a sequence of images. They have proposed a statistical approach which combined with Eigen-space transformation (EST) with canonical space transformation (CST) for feature transformation of spatial templates. Cunado, D. et al. (1997) proposed a method for evidence gathering technique. The proposed technique have been developed for a moving model, representing human thighs, and to provide a gait signature automatically from the motion of the thighs. Phillips, P. J. et al. (2002) proposed a baseline algorithm for the challenge problem of human
identification using gait analysis. Phillips, P. J. et al. (2002) worked on the baseline algorithm and with a large set of video sequences to investigate important dimensions of gait identification challenge problem, such as variations due to view point, footwear, and walking surface. Sarkar, S. et al. (2005) proposed a simple method, the baseline algorithm and a dataset to establish a minimum model for performance evaluation. Their method involves finding the maximum correlation of the binarized silhouettes as a similarity measure and a very simple approach to determine the gait period. BenAbdelkader, C. et al. (2001) have presented a new technique for motion-based recognition of individual gaits. They have proposed a method of gait recognition that uses similarity plots. First the PCA has been applied on a set of training similarity plots to map them to a lower dimensional space. Then recognition of gait has been carried out through standard pattern classification within sampler space. They have used K-nearest neighbor rule and the Euclidean distance measures for the gait recognition. Using the proposed approach they have obtained a recognition rate of 93%.

Boulgouris, N. V. et al. (2007) have proposed a technique for gait recognition based on the matching of body components. They have used the manually extracted and labeled silhouettes for gait recognition. Bamberg, S. J. M. et al. (2008) have developed a wireless wearable system Gait Shoe that provide quantitative gait analysis. The Gait shoe has proved highly capable of detecting heel-strike and toe-off as well as estimating foot orientation and position. Wahab, Y. et al. (2008) designed a sensor based on more promising MEMS technology for measuring foot pressure measurement. Wang J. M. et al. (2008) have introduced Gaussian process dynamic models for non-linear time series analysis to learn models of human pose and motion from high dimensional motion capture data. The model proposed by Wang et.al comprises a low-dimensional latent space with associated dynamics, as well as a map from the latent space to an observation space. Samangooei, S. and Nixon, M. S. (2008) have proposed a set of semantic traits discernible by humans at a distance outlining their psychological validity.

Senanayake, C. et al. (2009) have proposed a system that was developed with the intention to provide clinicians a solution to acquire gait parameters and detect anomalies easily. In the proposed system they have used four force sensitive resistors and two inertial sensors to obtain ground contact force measurement and knee joint angles respectively during walking. Guo, B. and Nixon, M. S. (2009) have investigated a computationally efficient solution to select the most important features for gait
recognition. The technique applied by them is based on mutual information (MI) which evaluates the statistical dependence between two random variables. To assess the proposed method experiments were carried out on a model-based gait feature set and a model free symmetry gait data. The results showed that the MI-based method has good application capability in gait feature selection. Al-Huseiny, M. S. et al. (2009) have described a new technique to extract the boundary of a walking subject to predict movement in missing frames. The technique proposed by them uses a level sets representation of training shapes and uses an interpolating cubic spline to model the eigenmodes of implicit shapes.

Goffredo, M. et al. (2010) have presented a new method for viewpoint independent gait biometrics. The proposed system describes a view-invariant markerless model based approach for gait biometrics. Gait features are derived based on the pose estimation of the joint positions of walking subject. Goffredo, M. et al. (2010) have proposed a new method for viewpoint independent marker less gait analysis that does not require camera calibration and works with a wide range of walking directions. These properties make the proposed method particularly suitable for gait identification in real surveillance scenarios where people and their behavior need to be tracked across a set of cameras.

Yoo, J. H. and Nixon, M. S. (2011) have proposed a new method for an automated marker-less system to describe, analyze and classify human gait motion. They have used a set of 2D stick figures to represent the human gait motion and the features based on motion parameters are determined from the sequence of extracted gait figures. A K-nearest neighbor classifier is used to classify the gait patterns. Bouchrika, I. et al. (2011) have investigated the translation of gait biometrics for forensic use. They have used the locations of ankle, knee and hip to derive a measure of match between walking subjects in image sequence. The match is achieved by instantaneous posture matching which determines the difference between the positions of a set of human vertices.

Goshvarpour, A. and Goshvarpour, A. (2012) have introduced nonlinear analysis of biological data. They have evaluated nonlinear and chaotic dynamics of gait signals. The gait data of healthy subjects walked in slow and fast paces has been considered in their work. Depending on the gait data considered for the work the Poincare plots, Hurst Exponents and Lyapunov exponents of gait signals were calculated. Amin, T. and Hatzinakos, D. (2012) have worked on the recognition performance of dynamic features extracted from different parts of human body in an appearance based setup. Their
experimental results has shown that dynamics of lower leg and lower arm are of utmost
importance for building an efficient gait recognition system.

Sinha, T. S. et al. (2011) have proposed a knowledge-based model for recognition of
abnormal foot. They have used ANN for formation of knowledge-based model called
GAIT_MODEL and GA has been used for recognition of abnormal foot. An algorithm
NGBAFRR (Neuro-Genetic based Abnormal Foot Recognition) has been proposed and has
been tested with 20 subjects. The experimental results has been found to be very
satisfactory.

Poppe, R. (2007) has presented an overview on vision-based human motion analysis. The
c characteristics of human motion analysis has been described briefly. The analysis is
divided into modeling and estimation phase. The goal of the modeling phase is to
construct function that gives the likelihood of the image given set of parameters. Various
human body models has been proposed by the researchers for the analysis of human
motion. The estimation process is concerned with the finding the set of pose parameters
that minimize the error between the observation and the human body model. Two classes
of estimation techniques has been proposed: top-down approach and bottom-up approach.

Troje, N. F. (2002) has proposed a framework for analysis of biological motion and also
to synthesize new motion patterns. The developed framework transforms the biological
motion patterns into a representation that can be treated as analysis of biological motion
as a linear pattern recognition problem. A linear classifier has been constructed that is
going to discriminate between male and female walking patterns.

Kale, A. et al. (2004) have proposed a view based approach for recognizing humans from
their gait. They have considered two image features, 1) width of the outer contour of the
binarized silhouette, 2) binary silhouette itself. Two different methods have been
employed for obtaining the observation vector from the image features. In one method a
low dimensional observation sequence is derived from silhouettes during a gait cycle and
an HMM is trained for each person. Identification has been done by evaluating the
probability that a given observation sequence was generated by particular HMM model.
In the second method the distance between an image feature and exemplar has been used
to estimate the probability.

Lozano-Ortiz, C. A. et al. (2010) have proposed an approach for human gait classification
using the Vertical ground reaction force (vGRF). They have applied the principal
component analysis and two artificial neural networks, multilayer feed forward and self
organized maps (SOM), to classify and cluster the gait patterns from normal subjects and subjects with lower limb fractures.

Li, X. et al (2008) have proposed a new method of human identification recognition and gender recognition. They have segmented the human silhouette into seven components, head, arm, trunk, thigh, front-leg, back-leg and feet. The effectiveness of these seven components have been analysed for human identification and gender recognition. Experimental results shows that the gaits of the trunk and front-leg are the important factors for gender recognition.

Yu, S. et al. (2009) have proposed new gender classification method that combines human knowledge with image features. The Gait Energy Images (GEIs) have been considered for their proposed method. Each GEI has been segmented into fine components: head and hair, chest, back, waist and buttocks, and legs. By considering these five components the classification has been done using SVM. Yoo, J. H. et al. (2005) has developed an automated system to classify gender by utilizing a set of human gait data. They have used SVM classifier to classify gender in the gait patterns. These system consist of three stages first is detection and extraction of moving human body and its contour from image sequence, in second stage extraction of human gait signature by the joint angles and body point and in the third which is final stage motion analysis and feature extraction for classifying the gender in the gait pattern. Wang, W. et al. (2012) has proposed a method for pedestrian gait classification and analyzed different human gait type into a series of consecutive postures types. With the help of back ground subtraction method silhouettes are extracted and Bayesian classifier is proposed to recognize the gait classification of human motion, and indicate that to increase the performance more test is required. Sabir, A. et al. (2013) has describes a method for gender classification based on human gait for these they focus on three main type of features Spatio-temporal model, Leg Motion detection and statistical wavelet model. These features have different characteristics to be used in gender recognition system based on gait recognition. K-nearest neighbors and support vector machine are the two different classifier used in the proposed work. Zhang, Y. et al. (2013) have used three different contour features Procrustes mean shape (PMS), tangent angle features, shape context descriptor are fused for gait recognition through a score level information fusion framework. PMS is used for compact representation of gait sequence. The two features tangent angle features, shape context descriptor are based on PMS only. All these features are fused at match score level with five different rules. Lu, J. et al. (2013) have investigated the problem of human
identity and gender recognition from gait sequence in different walking directions and style. They use background subtraction for finding silhouettes and cluster them into several clusters. The features used in the proposed method are cluster based averaged gait image (C-AGI). They also proposed a sparse reconstruction based metric learning method to learn a distance metric to minimize the intra class sparse reconstruction errors and maximize the inter class sparse errors.

Tang, J. et al. (2014) have proposed a method for modeling human body and extracting the gait features for identifying the human subject. 2.5 dimensional data is mapped onto space by Gaussian curvature and mean curvature based gait images for characterizing the body effectively. They have used DCT for Compression and PCA for features extraction. Darwish, S. M. et al. (2014) have use new method for handling inaccurate information about gait features is of fundamental important. They have proposed a method which deals with the design of an intelligent gait recognition system using type-2 fuzzy k-nearest neighbor. They also uses Principal component analysis to remove correlation between the features and also to reduce its dimensionality. The proposed method helped to distinguish between normal and abnormal and suspicious walk of a person so that an alarming action may be taken well in time. Bhowmick, S. et al. (2013) have proposed novel feature extraction techniques for classifying human gait irrespective of different cloths. In this proposed method OU-ISIR gait database is used and a sequence of silhouette frames has been obtain. They have tried to develop a statistical based classifier using Naïve Baye’s condition probability function. Receiver operating characteristic curve is used to evaluate the performance analysis of baye’s classifier.

Li, X. et al. (2013) have proposed a new gait recognition method called structural gait energy image (SGEI) which combines the advantage of GEI and model based methods. The fusion of GEI and SGEI is conducted for classifier. In this proposed work they considered two different conditions like clothing and varying variations. The database used is CASIA (B) and get a recognition rate upto 89%. Bogale, M. A. et al. (2012) the objective of their study is to investigate the possible application of granular computing to qualify gait parameters within seven gait phases. They have used fuzzy granular computing on the vertical ground reaction force (VGRF) and Surface electromyography data to obtain respective characteristics values for each gait phase. In these study they tested these approach on 10 patients to identify abnormities. Kale, A. et al. (2003) have described that gait recognition algorithms work best when presented with images where the persons walks parallel to the camera ie the image plane. They describe that if the
person is far enough from the camera, it is possible to synthesize a side view can from any other arbitrary view using a single camera. They have proposed a simple camera calibration scheme for this. Kale, A. et al. (2002) have proposed a view based a view based approach to recognize humans through gait and a set of stances or key frames that occur during the walk cycle of an individual is chosen. A continuous HMM is trained using several lower dimensional vector sequence extracted from the video and human identification performance of the proposed scheme is found to be quite good when tested in the natural walk conditions. Aggarwal, J. K. et al. (1999) have given the overview of the various tasks involved in the motion analysis of the human body. They have focus on few major areas related to related to interpreting human motion first is motion analysis involving human body parts and second is tracking of human motion using single or multiple cameras. After success full matching the moving human image from one frame to another in image sequences understand the human movements or activities comes naturally. Xu, S. and Zhang, Q. (2010) have proposed a novel gait recognition algorithms based on fuzzy principal component analysis for gait energy image (GEI). Firstly the original gait sequence is preprocessed and gait energy image is obtained. They have used NN classifier for feature classification. They have able to achieve higher recognition performance. Nandy, A. et al. (2014) have discussed the robustness of gait identification irrespective of small fluctuation in the subject’s walking pattern. With the help of silhouette gait sequences the gait energy image is computed. The three independent component such as head node, body torso and leg region are separated from subject GEI in accordance to body segment ratio. Arai, K. and Andrie, R. (2013) have proposed a model is based on morphological operation and is similar to the conventional skeleton model which allows calculations of angles of human body, and also proposed a method for gender classification using gait walking skeleton model. It also confirmed that the proposed method accuracy of gender classification with high percent correct classification 85.33%. Xiao, F. et al. (2010) have presented a skeletons based approach for gait recognition. They have first extract gait features from image sequences and gait recognition is perform and achieved great accuracy rate with CMU data set. Ng, H. et al. (2009) have proposed a new approach for extracting human gait features for a walking human based on the silhouette images. The new approach involves any step like clearing the background noise of image by morphological opening and applying morphological skeleton to obtain body skeleton. From the experiment they observed that the proposed system is feasible as satisfactory result have been achieved. Tafazzoli, F. et al. (2014)
have used CASIA dataset for experiment and investigated the effect of discarding irrelevant or redundant gait features by employing genetic algorithms to select an optimal subset of features for improving the performance of a gait recognition system. DeCann, B and Ross, A. (2010) have described that the main objective of this study is to move beyond traditional image acquisition modalities and explore the issues of object detection and human identification at night, for these problem a spatiotemporal gait curve that captures the shape dynamics of a moving human silhouette is employed. The outcome of this work is an efficient algorithms and human identification. Zadeh, H. G. et al. (2011) have focused on human behavior recognition from video images. They have used PCA technique and neural network for increasing velocity and so recognition accuracy. Their proposed method, which can be used in immunity system for human recognition based on walking gait analysis through variability with environment conditions. Foster, J. P. et al. (2003) have proposed a technique that uses the dynamic temporal signal as a signature for automatic gait recognition. The main focus of their work is to extract temporal information from gait with low computational cost. The proposed technique uses a masking function to determine area and captures low dimensional temporal signature of the subject. By using the extracted dynamic signatures on the SOTON database a 75% correct classification rate has been obtained. Okusa, K. and Kamakura, T. (2013) have worked on the problem of analyzing and classifying frontal view gait video data. They have designed the frontal view human gait model for the gait authentication. In their work scale changing, human movements and speed changing parameters of the frontal view gait data have been considered. These parameters are estimated using the statistical registration. The K-nearest-neighbour classifier has been applied on the estimated parameters to perform the human gait authentication. Hofmann, M. et al. (2012) have proposed a new person identification method by combining an improved gait recognition method with an adapted low resolution face recognition method. They have used a new automated segmentation technique based on alpha-matting. The Gait Energy Image (GEI) has been used for gait recognition. Instead of using binary silhouettes the alpha channel from alpha matting has been used and called as Alpha Gait Energy Image (α-GEI). The face recognition has been done using the classical eigenface method. By combining both the face and gait recognition methods, the results shows that there is a significant improvement in performance for Human ID Gait Challenge. Wang, L. et al. (2004) have proposed an efficient algorithm for personal recognition based on the fusion of static and dynamic body biometrics. They have used Procrustes shape analysis method to obtain a
compact representation for the appearance of the body shape from spatio-temporal pattern of walking action. A model based approach has been used to extract the dynamic information of gait, (i.e. the track the walker and to obtain the joint-angle trajectories of lower limbs). Both the static and dynamic cues have been used independently for recognition using nearest exaampler classifier. To improve the performance of identification and verification the static and dynamic cues of gait has been fused using different combination of rules. Liu, L. et al. (2011) have proposed a simple effective gait recognition method based on outermost contour. They have used an adaptive silhouette extraction algorithm to obtain the normalized silhouette images from the gait image sequence. The feature extraction has been carried out using the proposed method based on outermost contour. PCA has been used to reduce the dimensionality of the distance signals and then the gait features have been computed. For recognition multiple discriminant analysis (MDA) with nearest neighbor classifier has been used. Experimental results indicates that by using the proposed method high accuracy can be obtained for gait recognition. Muramatsu, D. et al. (2013) have proposed a method for gait recognition for criminal investigation. In the proposed method they have fuse direct cross-view matching scores. Here two set of images are considered i.e. the probe set and the gallery set. Gait features from different views are matched without using a View Transformation Model (VTM). The matching scores are fused for authentication. Hossain, E. and Chetty, G. (2011) have proposed a novel approach for human identification based on the fusion of profile face and gait biometric signals. Their approach is based on transforming the features in PCA-LDA subspace. The classification has been carried out with multivariate Gaussian classifiers. The experimental evaluation of the proposed approach found to be a powerful method for capturing the inherent multimodality in walking gait patterns. Davis, J. W. and Gao, H. (2004) have presented a framework for recognition of gender from walking movements using an adaptive three-mode PCA. According to their approach prototype male and female walkers are initially decomposed three mode basis sets representing the body posture, temporal trajectories and gender changes. The multi-modal decomposition of the data is suitable for incorporating expressive weights on motion trajectories to bias the estimation of gender. The method embeds an expressive weight to each motion trajectory in the sub-space and automatically learns the necessary weight values from gender-labeled training data. This approach can be adapted to different recognition environments (physical and perceptual
Ekinci, M. (2006) has presented a view-invariant approach for human identification at a distance using gait recognition. A simple and effective approach has been described for gait recognition based on PCA. The distance vectors (i.e. the difference between the bounding box and silhouette) have been extracted using 4 projections of the silhouette. The gait cycle has been estimated using the normalized correlation of the distance vectors. Then eigenspace transformation based on PCA has been applied to the time varying distance vector and Mahalanobolis distance based supervised pattern classification has been performed for human identification. Guillen, E. et al. (2009) have proposed a simple gait recognition system with feature subtraction on a bundle rectangle drawn over the walking person. They have analyzed five classifiers such as height, width, area, diagonal’s angle and total spectral power. By considering these five classifiers the reliability of the proposed system is obtained near to 98%. Xu, D. et al. (2006) have presented a gait recognition approach based on a matrix representation. According to their approach first the binary silhouettes are averaged over one gait cycle. Then a matrix based unsupervised algorithm coupled subspace analysis (CSA) has been employed as a preprocessing step to remove noise and retain the most representative information. A supervised algorithm discriminant analysis with tensor representation has been applied for classification. This matrix based approach has much better performance for gait recognition compared to other algorithms. Chacon-Murguia, M. I. et al. (2012) have proposed an automatic visual gait analysis approach that has the capability to detect hip, knees and ankle positions in the different gait phases as well as gait cycle analysis, cycle time, step and stride length, speed and cadence. In the proposed method a direct kinematic model of the legs has been obtained by assigning a coordinate system according to the DH algorithm. The method is also able to deal with the occlusion situations that occur in mid-stance and mid-swing stages. Mansour, R. F. (2012) has proposed effective multi-view gait recognition based on motion contour (MVGRMC). The background modeling has been done from a video sequence. The moving foreground objects in the individual frames have been segmented using the background subtraction algorithm. The morphological skeleton operator has been employed to track the moving silhouette of the walker. When a video sequence is fed to the proposed system, it recognizes the gait features and the humans based on self-similarity measures. Begg, R. K. et al. (2005) have proposed a approach for automatic recognition of young-old gait
types from their respective gait patterns by employing an artificial intelligence technique, Support Vector Machines (SVM). They have considered the Minimum Foot Clearance (MFC) data of 30 young and 28 elderly subjects for a continuous walk on a treadmill. The gait features have been extracted from individual MFC using two types of distributions: Histogram and Poincare plots. These extracted features were used to train the SVM. The experimental result shows that SVMs are capable of automatically recognizing gait pattern of young and old very effectively. Arai, K. and Asmara, R. A. (2014) have proposed a gender classification method based on Gait energy Motion (GEM) derived using wavelet analysis of human gait moving pictures. The proposed method has been experimented on the CASIA Database. The results shows that using the extracted features of wavelet coefficients there is an improvement in gender classification accuracy. Asif, S. et al. (2014) have proposed a time efficient Human gait identification system. First they have extracted the Human silhouettes using temporal background subtraction on video frames. Then the contours have been extracted from the foreground silhouette images. Three bounding boxes are drawn around the contoured human image: 1) upper part for arm movement 2) middle part for thigh and knee angles 3) Lower part for leg movement, knee and ankle angles. Thigh, knee, ankle angles and bounding box widths have been used as gait signatures in their work. SVM has been used for classification. Liu, Z. and Sarkar, S. (2007) has proposed a new scheme of recognition by fusing gait and face. The proposed method relies on computation of distances based on selected discriminatory gait stances. They have used the hidden markov model (HMM) to identify the salient stances. Then an averaged representation for these stances has been obtained using eigenstance shape model. For face they have used the elastic bunch graph matching based face recognition method. The experimental result shows that biometric combination is an effective strategy for improving performance of hard biometric problems, involving template comparision across indoor and outdoor conditions and across months. Tanawongsuwan, R. and Bobick, A. (2001) have proposed a method of gait recognition considering only the trajectories of lower body joint angles projected into the walking plane. The work begins with the position of the 3D markers projected into the walking plane. They have proposed a simple method for estimation of planner offset between the markers and the underlying skeleton and joints. They have fixed the number of footsteps and time normalize the trajectories to compensate the variations from one instance to another. The recognition has been done using the simple nearest neighbor algorithm with Euclidean distance as measurement criteria.
Liu, Z. and Sarkar, S. (2006) have presented a improved gait recognition method by normalizing the dynamics and focusing on shape information. They have normalized the gait dynamics using population Hidden Markov Model (pHMM). The states of the pHMM represent gait stances. From the gait stances gait cycle of fixed length has been obtained. Then the distance between the two gait stances have been computed in the linear discriminant analysis space. The experimental result concludes that dynamics-normalization has improved the gait recognition performance. The other two components of their algorithm: the LDA stance shape and the morphological-based distance computation have also improved the performance. Liu, Z. and Sarkar, S. et al. (2004) have came up with a robust representation for gait recognition that is compact, easy to construct and efficient matching. First they have averaged the silhouettes over one gait cycle. Then the recognition has been done on the basis of Euclidean distance between these averaged silhouettes. Yam, C. Y. et. al. (2001) has described a new system that extends the feature based approach to recognise people by the way they walk and run. A bilateral symmetric and coupled oscillator is the key concept that underlies this model, which includes both the upper and the lower leg. They have extracted the gait signature from the phase-weighted magnitude of the lower order Fourier components of both the thigh and knee rotation. A new model based technique has been developed for the thigh and lower leg and achieves fewer parameters by using the property of coupled oscillators. This new model has been shown to good effect in recognition of subjects by the way they walk and by the way they run, with a relatively better recognition rate for walking as compared to running. Foster, J. P. et al. (2001) proposed a new area based metric, called gait masks, which provides statistical data intimately related to the gait of the subject. The gait masks can also be used on subjects other than humans to provide information about the gait cycle of the subject. The proposed new area based metric for gait recognition that produces good results on a small database. The recognition is possible by only using the temporal components of the silhouette sequence. Matovski, D. S. et al. (2010) have presented the first principled study that examines the effect of elapsed time on gait recognition. It have been shown for the first time that elapsed time does not affect recognition significantly in the short to medium term using empirical evidence. By controlling clothing, a Correct Classification Rate (CCR) of 95% has been obtained. Clothing drastically affects performance regardless of elapsed time. Three views of the walking subject has been considered their work: top view, side view and front view. The Euclidean distance measure and k-NN classifier have used in their work. It has been
demonstrated for the first time that gait can be used as a reliable biometric trait in the short and medium term if all covariate factors are accounted properly. Wagg, D. K. and Nixon, M. S. (2004) develop a new automated marker less motion capture system for the analysis of walking people. They employ global evidence gathering techniques guided by biomechanical analysis to robustly extract articulated motion. This forms a basis for new deformable contour models, using local image cues to capture shape and motion at a more detailed level. And also extend the greedy snake formulation to include temporal constraints and occlusion modelling, increasing the capability of this technique when dealing with cluttered and self-occluding extraction targets. Cunado, D. et al. (1995) shown not only to extract a moving person, but also to extract and concurrently provide a gait signature for use as a biometric. Authors show the natural relationship between the bases of these approaches, and the results they can provide. As such, these techniques allow for gait extraction and description for recognition purposes, and with known performance advantages of a well-established vision technique. Model-based approaches to gait feature extraction provide a unified analytic procedure where results can be verified by matching with image data. Evidence gathering is well-known for its ability to handle noise and occlusion, as increasingly occurrent in image sequences. Wagg, D. K. and Nixon, M. S. (2004) developed a new model-based extraction process guided by biomechanical analysis for walking people, and analyse its data for recognition capability. Hierarchies of shape and motion yield relatively modest computational demands, while anatomical data is used to generate shape models consistent with normal human body proportions. Mean gait data is used to create prototype gait motion models, which are adapted to fit individual subjects. Goffredo, M. et al. (2009) presented a new method for viewpoint independent gait biometrics. The system relies on a single camera, does not require camera calibration, and works with a wide range of camera views. This is achieved by a formulation where the gait is self-calibrating. These properties make the proposed method particularly suitable for identification by gait, where the advantages of completely unobtrusiveness, remoteness, and covertness of the biometric system preclude the availability of camera information and specific walking directions. The approach has been assessed for feature extraction and recognition capabilities on the SOTON gait database and then evaluated on a multiview database to establish recognition capability with respect to view invariance. They have taken an important step in deploying gait biometrics for the analysis of surveillance video. A view-invariant markerless model-based approach for gait biometrics has been described. Gait features are derived based on
the pose estimation of the joint positions of walking subjects. A novel 2-D markerless view-independent gait analysis algorithm has been presented: The method does not need camera calibration or prior knowledge of subject pose. Since the choice of the cameras’ characteristics is a key point for the development of a smart surveillance system, the performance of the proposed approach has been measured with respect to different video properties. Bazin, A. I. et al. (2005) examined the fusion of various gait metrics in a probabilistic framework. Using three gait modalities they describe a process for determining probabilistic match scores using intra and inter-class variance models together with Baye’s rule. We then propose to fuse these modalities based on established fusion rules with weights determined in a principled manner. Using a large publicly available database we show improvements through fusion, both in terms of verification accuracy and class separation. Goffredo, M. et al. (2008) presented a new method for viewpoint independent markerless gait analysis. The system uses a single camera, does not require camera calibration and works with a wide range of directions of walking. These properties make the proposed method particularly suitable for identification by gait, where the advantages of completely unobtrusiveness, remoteness and covertness of the biometric system preclude the availability of camera information and use of marker based technology. Hayfron-Acquah, J. B. et al. (2001) described a new method for automatic gait recognition based on analysing the symmetry of human motion, by using the Generalised Symmetry Operator. This operator, rather than relying on the borders of a shape or on general appearance, locates features by their symmetrical properties. This approach is reinforced by the psychologists’ view that gait is a symmetrical pattern of motion and by other works. They applied fusion method to two different databases and derived gait signatures for silhouettes and optical flow. The results show that the symmetry properties of individuals’ gait appear to be unique and can indeed be used for recognition. The aim of this paper is to support the psychology view that the symmetry of human motion can be used for recognition. Goffredo, M. et al. (2008) presented a 2D gait analysis system which is completely markerless and extracts kinematic information by analyzing video sequences obtained from an RGB video camera. These properties make the proposed approach particularly suitable in medical contexts where visual gait observation is still a recognised procedure or the invasiveness and high costs of marker-based systems cannot be afforded. A new method for 2D markerless gait analysis has been presented. It extracts kinematic information by analyzing video sequences with a silhouette-based approach based on the human body anthropometric proportions.
Bouchrika, I. and Nixon, M. S. (2006) proposed a new approach to extract human joints (vertex positions) using a model-based method. Motion templates describing the motion of the joints as derived by gait analysis, are parameterized using the elliptic Fourier descriptors. The heel strike data is exploited to reduce the dimensionality of the parametric models. They propose a model-based method to extract moving joints via evidence gathering technique. Spatial model templates for human motion are derived from the analysis of gait data collected from manual labelling. Model templates are represented in a parametric form based on elliptic Fourier descriptors. Gait knowledge is exploited via heel strike extraction to reduce the parameter space dimensionality and therefore reduce the computational load of the Hough Transform being used in the extraction process. The described method is proved to work for both indoor and outdoor environments with potential to localize joint positions with better accuracy.

Rajpoot, N. and Masood, K. (2005) have described a new approach which uses projection of spatiotemporal surface onto subspace spanned by appropriate axes. They have presented two new algorithms for gait recognition which uses projection on subspace of kernel induced higher dimensional spaces using PCA and Fisher’s LDA. They have used the dataset which contains different subject walking at three different viewing angles in outdoor environment and they are able to achieve high accuracy rate. Bauckhage, C. et al. (2005) have analyzed gait from different angle and shall examine its use as a means to deduce the physical condition of people. They have used support vector machine for classification of two class problem. They have presented a homeomorphism between 2D lattices and binary shapes that provides a robust vector space embedding of body silhouettes. With the help of experiment results they are able to detect abnormal gait. BenAbdelkader, C. et al. (2002) presented a correspondence free method to automatically estimate the spatio-temporal parameters of gait of walking person from video. They have used calibrated camera the stride length has been estimated. The database used by them having 17 subjects and 8 samples of each is used to verify with an Equal Error Rate of 11% and correctly identified with a probability of 40%. Davis, J. W. and Taylor, S. R. (2002) have presented an approach for recognizing human walking movement using low-level motion regularities and constraints. They have used Biomechanical features for classification. After the experimental result they are able to distinguish walking example across multiple speeds from other non-walking locomotion. Cedars, C. and Shah, M. (1994) have made the survey on recent development in motion-based recognition. These
deals with the recognition of object or motion directly from the motion information extracted from sequence of images. Finding an appropriate representation for the object or motions and matching of some unknown input with a model are the two main steps in this approach. Han, J. and Bhanu, B. (2006) have proposed a new spatio-temporal gait representation called gait energy image, to characterize human walking properties for individual recognition by gait. To address this problem they have generate a series of new GEI template by analyzing the human silhouette distortion under various conditions. Learned features are used for recognitions. The experimentation results show high competitive performance with respect to current gait recognition approaches. Huang, Y. et al. (2010) have proposed a new distance measure for face recognition and human gait recognition. They have formulated an integer programming problem to compute the distance from face image and average silhouette image from one gallery images. They have also enforce a spatial neighborhood constraint by only neighboring features that are given spatial distance to be considered for feature matching. They have used CMU PIE database and FERET database for experiment. Schuldt, C. et al. (2004) have demonstrated how features can be used for recognizing complex motion problem. They have constructed video representation in terms of local space time features and integrate such representation with SVM classification scheme. They have introduce new database which contains 2391 sequence of six human action performed by 25 people. With the help of proposed method they have able to achieved high accuracy rate. Judge, J. O. et al. (1996) have made an study that aging is associated with a reduction in gait velocity, which is due to a shortened step length, with the help of this study they are able to get relationship between joint kinetics and step length. They have proposed a method gait kinetics and kinetics were measured during usual pace gait in different subject and different age. With the experiment conclusion was that older subjects had lower ankle plantar flexion power during the late stance phase of gait and appeared to compensate for reductions in plantar flexion power by increasing hip flexor power. Boulgouis, N. V. and Chi, Z. X. et al. (2007) have proposed a new feature extraction process is proposed for gait representation and recognition which is based on radon transformation of binary silhouettes. In this process each gait sequence is described using a low dimensional feature vector consisting of selection radon template coefficients. With the help of test feature vector, gait recognition and verification is achieved by appropriately comparing it to feature vectors in a reference gait database. with the help of this system very considerable improvement in recognition performance. Zhao, G. et al.
(2006) proposed work fractal scale wavelet analysis applied to describe and automatically recognize gait. Optimal wavelet based on generalized multi-resolution analysis is used to improve the recognition rate. Combination of fractal scale and wavelets moment improves the recognition rate. Barton, J. G. and Lees, A. (1997) have proposed an automated method of diagnosis of gait patterns using neural network. They have trained the neural network to distinguish three gait patterns: normal walking, simulation of leg length difference and a simulation of leg weight asymmetry. The gait patterns are represented by fast Fourier transformation coefficients of hip-joint angle and knee-joint angle of a single step. Their experimental result shows that the trained neural network could recognize the gait patterns at a correct assignment ratio of 83.3%. Lublinerman, R. et al. (2006) have proposed a model (in)validation technique for gait recognition. They have considered two commonly used models: Fourier Descriptors and Vectors of Widths for describing silhouette of each frame. Then each sequence has been modeled as a linear time invariant system that captures the dynamics of the frame description vectors in time. SVM has been used for recognizing the activities using similarity measures through model (in) validation. Kovac, J. and Peer, P. (2014) have proposed a skeleton model based gait recognition system that focus on modeling gait dynamics and eliminates the influence of subjects appearance on recognition. Further they have tackle the problem of walking speed variation and proposed a space transformation and feature fusion that influences the recognition performance. Derlatka, M. (2014) has presented an analysis of influence of selected psychophysical parameters on the quality of human gait recognition. The factors such as: body height (BH), body weight (BW), the emotional condition, the physical condition, previous injuries have been considered for analysis in his work. He has considered the ground reaction force (GRF) data. The classification has been done using modified k-Nearest Neighbour algorithm. Yoo, J. H. et al. (2008) have proposed a new method of recognizing humans by their gait using back-propagation neural network. They have used the 2D stick figures that have been extracted from the gait silhouette. In their work 27 parameters have been considered as gait features for recognition of the human gait. By using the enhanced back-propagation neural network on SOTON database they have obtained a recognition rate of 90%.

Cisi, R. R. L. et al. (1999) have proposed a model that use the artificial neural network to map the EMG signals and joint dynamics in the lower-limb.

Nacy, S. M. et al. (2013) have developed a method for identifying dynamic model of the human lower limb during complete gait cycle. The lower limb has been simulated as
three link robotic manipulator. The foot has been simulated as two right angle triangles. They have analyzed the variation of four angles: thigh angle, knee angle, ankle and foot angle. Verma, D. S. M. and Sujatha, S. (2014) have developed an inverse dynamics model for the single support (SS) phase of gait to study the contribution to the ground reaction force (GRF). The acceleration of body’s center-of-mass has been expressed as the summation of the weighted kinematics of individual segments. The developed model will be used to model asymmetric gait where kinematics of the segments of the right and left sides vary. Hosain S. M. E. and Chetty, G. (2011) have proposed a new technology for person identification using physiological and behavioural biometrics. In their experimental work the images of side face and gait images have been considered. They have achieved a recognition rate near about 100% from the experiments. BenAbdelkader, C. et al. (2002) have come up with a parametric method to identify people automatically by using the height and stride parameters of their walking gait. The proposed method is view-invariant and computes four gait variables from low resolution video. The variables used in their work are apparent height (i.e. mean and amplitude of vertical oscillation) and stride dimensions (i.e. cadence and stride length). The estimated accuracy for identification is about 47% for a dataset of 41 people with fronto-parallel image sequence, and 65% for a dataset of 17 people with non-fronto-parallel image sequence. Nandini, C. et al. (2011) have proposed a new approach for human identification using gait metrics. They have extracted the gait feature of an walking person using hough peak, area of the bounded box, the principal diagonal and its orientation, height and width. It has been observed that the proposed methodology works efficiently by combining the geometrical features and the templates, and has been tested on CASIA datasets. Hosseini, N. K. et al. (2013) have suggested a method to recognize humans in video by their gait using the silhouettes. The averaged silhouette has been used to represent the gait cycle. The PCS method has been applied to reduce the dimensionality of the features. They have used the Euclidean distance measure to compute the distance between test sample and train sample in the recognition stage. Luengo, I. et al. (2005) have proposed an automatic emotion recognition method based on prosodic features. They have experimented to automatically identify human-emotions from an emotional speech. To carry out the experiment they have used three classifiers: one using spectral features and GMM and Second with features and SVM and last one with prosodic features and GMM. They have calculated 86 prosodic features and developed an algorithm is selected most relevant ones. Mary, L. and Yegnanarayana, B.
(2008) have presented a new approach for extracting prosodic features directly from the speech signal that is useful in the application such as language and speaker recognition. Their approach eliminates the requirement of automatic speech recognizer. They have considered the knowledge of VOPs that can be detected automatically from the Hilbert envelope of LP residual of Speech signal. They have extracted syllable-like region which is the region between two successive VOPs and various parameters have been obtained such as duration, energy variations. Mohammadi, G. et al. (2011) presented the experiments on personality perception an unconscious process that take place when an human comes in contact with an unacquainted person. The personality assessment done by humans have been used as features to distinguish between professional and non-professional speakers. They have carried out the same task with prosodic features for comparison. Then they have combined both the prosodic features and the personality assessments to distinguish between professional and non-professional speakers. Their experimental results provide an accuracy of 90% when both are combined. Goldwater, S. et al. (2010) have analysed and investigated the errors of two state-of-the-art recognizers on conversational speech with the help of mixed effects regression model. As per their work higher error rates has been obtained for the words those with extreme prosodic characteristic, discourse markers and doubly confusable pairs also have high error rates. They have also proposed that doubly confusable pairs, rather than high neighbor density, may better explain phonetic neighborhood errors in human speech processing. Huang, S. and Renals, S. (2007) have proposed a solution to the question of exploiting prosody for language models to aid automatic speech recognition in the context of meetings. They have used automatic syllable detection algorithm and extracted syllable-based prosodic features to form the prosodic representation of each word. Investigation has been done on two modeling approaches. The first one is based on factor language model and second is based on hierarchical Bayesian framework to represent similar prosodic patterns. Lim, A. and Okuno, H. G. (2012) have proposed a method of recognizing human emotions using human-speech and human-gait analysis. They have combined the two modalities through common parameters: Speed, Intensity, Irregularity and Extent named as (SIRE) and a Gaussian Mixture Model has been trained using the independent samples from voice and gait. Barbulescu, A. et al. (2013) have proposed an approach for identification of the speaker using speech signals and 3D facial expressions. They have used spectral conversion by establishing statistical relation between the spectral envelopes of source and target speaker and the prosodic features has been introduced to exploit the alignment
between two speech signals. The Gaussian Mixture Model (GMM) has been used for different types of features: spectral, video-parameters, joint audio-video. For better conversion in speaking style the prosodic features have been extracted from time alignment information.

Chen, C. et al. (2009) have proposed an parameter-free tuning algorithm for gait recognition named multi-linear tensor-based learning without tuning parameter (MTP). They have employed a new method for automatic selection of the optimal reduced dimensions. Then the multi-linear tensor projections have been used to avoid small sample size problem. The advantage of MTP is that the dimensions can be automatically chosen by solving an eigen value problem. They have introduced a special laplacian matrix for the automatical selection of optimal dimension of a subspace and the laplacian matrix should be non-positive semi-definite. Cheng, J. C. and Moura, J. M. F. (1997) have proposed a model-based human walking recognition method in a dynamic scene. In their work the human body is considered as an articulated object connected by joints and rigid parts and the human walking has been considered as periodic motion. The posture of the subject has been determined by using an recognition algorithm that calculates the period and phase of the human-gait. From the obtained results they have concluded that content-based representation of humans in real video describes the humans according to their motion and shape.

Levit, M. et al. (2001) has described methodology for automatic detection of speaker alcoholization. Their work have been restricted to detection of considerable alcoholization that leads to a two class classification problem. They have proposed a new kind of signal interval for the extraction of prosodic features along with a method for their localization. They found that along with the fundamental frequency, energy, jitter and shimmer based characteristics play an important role in successful classification. Their experiments on unseen data results in a classification rate of 69%, when differentiating between alcoholized and not alcoholized speech. Ferrer, L. et al. (2003) have demonstrated that the improvement due to the prosodic knowledge can be realized without a speech recognizer. In their work thay have shown two new approaches for online detection of ends of utterances. The first one uses ASR output to obtain a prosodic model and a language model, that have been combined to improve system performance. In the second approach only the prosodic model has been used, relaying on features that can be extracted without word alignment. Friedland, G. et al. (2009) has defined as the
task of determining “who spoke when” given an audio track and no other prior knowledge of any kind is available. They have shown that how a selection of prosodic and other long-term features in combination increased the accuracy of speaker diarization. The results obtained in their work have been measured on standardized datasets (NIST RT) that shows a improvement of about 30% in diarization.

Vergyri, D. et al. (2003) has integrated different prosodic knowledge sources into a state of the art large vocabulary speech recognition system. They have investigated three models and each exploiting a different level of prosodic information. After that a further improvement is observed with the combination of all models, demonstrating that they each capture somewhat different prosodic characteristics of the speech signals.

2.4 Current Status

Sejdic, E. et al. (2015) have proposed a method of evaluating stride events which can be important for understanding the changes in walking due to aging and neurological diseases. They have developed a method to compute the time factors of heel strike and toe-offs for both feet of human-gait using a tri-axial accelerometer. The proposed algorithm in their work validates the accuracy against the stride interval time obtained through a motion capture system for healthy and neurologically diseased subjects.

Handzic, I. and Reed, K. B. (2015) have focused on the motion that constitute human-gait and to reduce the perception that a gait pattern is abnormal. The various gait abnormalities they have considered in their work were gait cadence, knee height asymmetry, spatial and temporal walking asymmetries and foot roll-over asymmetry. They have also examined the perception of gait by changing the two gait parameters namely asymmetric knee stiffness and shank mass asymmetry. From this analysis they have concluded that it is possible to alter the perception of a gait by manipulating different gait parameters.

2.5 Summary

In the present chapter, the literature survey made so far related to the work has been briefly discussed. It has been found that in the last 50 years, research in Determination of Behavioural Traits and Prosodic Features (DBTPF) has been intensively carried out worldwide in the field of Medical Sciences as well as in the engineering field through human-gait images. The technological progress in the past 50 years can be summarized by the following changes.

- From template-matching approach to knowledge-based approach
• From distance-based to likelihood-based methods
• From maximum likelihood to discriminative approach (GA method)
• From no commercial biometrical applications to commercial biometrical applications

It has been also found from the literature that knowledge-based models are still playing a vital role in any biometrical research work. Still there is a scope for DBTPF, using some high-end computing techniques and tools that have been carried out in the present work.