



**DEVELOPMENT OF LOCAL AND HOLISTIC
FEATURES USING FUSION IN GAIT ENERGY
IMAGES**

by

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LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
DCT	Discrete Cosine Transform
DSP	Digital Signal Processing
ED	Euclidean Distance
HMM	Hidden Markov Model
ICA	Independent Component Analysis
LBP	Local Binary Pattern
LDA	Linear Discriminant Analysis
PCA	Principal Component Analysis

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LIST OF SYMBOLS

av	Average
$Covar$	Covariance
D_C	City block distance
D_E	Euclidean Distance
D_M	Mahalanobis distance
d	Distance
$Eval$	Eigenvalue
$Evec$	Eigenvector
h	Height
I	Image

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Pengembangan Ciri-Ciri Tempatan Dan Holistik Menggunakan Gabungan Dalam Imej Tenaga Gaya Berjalan

ABSTRAK

Kajian ini adalah mengenai perkembangan sistem pengenalan biometrik automatik menggunakan imej tenaga gaya berjalan. Sistem pengiktirafan biometrik telah digunakan secara meluas dalam aplikasi penglihatan komputer seperti sistem keselamatan lapangan terbang, sistem pengawasan manusia dan pengumpulan bukti jenayah. Sesetengah akses pengenalan mempunyai kelemahan, oleh yang demikian kerjasama dari subjek diperlukan dan menjadi lebih sensitif terhadap perubahan alam sekitar dan fisiologi. Urutan gaya berjalan terdiri daripada data tidak bergerak dan boleh dimodelkan menggunakan teknik pembelajaran statistik. Kaedah yang dicadangkan untuk kajian ini terdiri daripada 5 peringkat iaitu teknik pra-pemprosesan, proses pengekstrakan ciri, pengurangan dimensi, pengelasan, dan gabungan. Peringkat pertama adalah teknik pra-pemprosesan yang mengira purata imej bayang untuk menangkap maklumat penting dalam data bayang gaya berjalan. Tahap kedua ialah proses pengekstrakan ciri dengan menggunakan DCT dan LBP. Transformasi Cosine Diskret (DCT) adalah perwakilan tekstur yang baik untuk imej 2D dan juga pemampat imej. DCT menentukan satu siri terhadap titik data dari segi sejumlah fungsi kosina berubah-ubah pada frekuensi yang berbeza. Sebaliknya, Corak Binari Tempatan (LBP) juga merupakan deskriptor tekstur yang hebat kerana ia membandingkan setiap piksel dengan jiran dengan menggunakan ambang. Kedua-dua DCT dan LBP digunakan pada purata bayang untuk mengekstrak ciri-ciri gaya berjalan penting. Tahap ketiga dipanggil proses pengurangan dimensi. Analisis Komponen Utama (PCA) digunakan untuk mengurangkan dimensi ciri gaya berjalan. Kaedah unjuran linier digunakan pada peringkat ini untuk menghapuskan ciri-ciri berlebihan dan menghilangkan bunyi bising dari imej gaya berjalan. Selain itu, pendekatan ini meningkatkan kuasa diskriminasi dalam ruang ciri apabila berurusan dengan maklumat frekuensi rendah. Pengagihan ciri dimensi rendah dalam ruang ciri diandaikan kepada Gaussian, oleh itu pengelas jarak Euclidean boleh menjadi pilihan yang lebih baik untuk peringkat klasifikasi. Untuk menghasilkan pengiktirafan gait yang lebih baik, kaedah gabungan jumlah wajaran digunakan untuk meningkatkan pemisahan kelas. Algoritma yang dicadangkan ini berasaskan bebas model yang menggunakan ciri bayang gaya berjalan untuk perwakilan imej gaya berjalan padat. Kerja ini telah dinilai dengan dataset penanda aras CASIA. Dari hasil eksperimen yang dijalankan, hasil menunjukkan bahawa kadar pengiktirafan terbaik adalah 97% apabila menggunakan 5 imej latihan dan satu imej ujian, imej tersebut diwakili menggunakan 100 pekali PCA, pekali DCT 50%, menggunakan kejuranan LBP 3 x 3 dan menggunakan kaedah gabungan jumlah wajaran. Pelaksanaan kaedah yang dicadangkan menggunakan kaedah gabungan jumlah wajaran menghasilkan prestasi yang mantap dari segi ketepatan pengiktirafan.

Development of Local and Holistic Features using Fusion in Gait Energy Images

ABSTRACT

This research is about the development of an automatic biometric identification system using gait energy images. Biometric recognition system has been extensively applied in computer vision applications such as airport security system, human surveillance system and criminal evidence gathering. However, some of these identification systems have their own drawbacks, therefore feedback from the subjects are needed in order to increase the sensitivity towards both environmental and physiological changes. Gait sequence consists of non-stationary data and can be modeled using a statistical learning technique. The proposed method for this research consists of 5 stages, namely pre-processing technique, feature extraction, dimensionality reduction, classifier and fusion. The first stage is pre-processing technique where the average silhouette images are calculated in order to capture the essential information in gait silhouette data. The second stage feature extraction process by applying Discrete Cosine Transform (DCT) and Local Binary Pattern (LBP). DCT defines a finite series of data points in terms of a sum of cosine functions fluctuating at different frequencies. On the other hand, LBP is also a great texture descriptor because it compares each pixel with its neighbours by using certain threshold value. Both DCT and LBP were applied on the average silhouette to extract important gait features. The third stage is called dimension reduction process by using linear projection method. Principal Component Analysis (PCA) is applied to reduce the dimension of gait features. A linear projection method is employed in this stage to eliminate redundant features and remove noise from the gait image. In addition, this approach also increased the discriminating power in the feature space when dealing with low frequency information. Low dimensional feature distribution in the feature space is assumed as Gaussian, thus the Euclidean distance classifier can be considered as a better choice for the classification stage. In order to produce better gait recognition, Weighted Sum Fusion rule is applied to enhance class separation. This proposed algorithm is a model-free base which uses gait silhouette features for the compact gait image representation. This work has been evaluated with a benchmark CASIA dataset. From the experiment conducted, result shows that the best recognition rate is 97% when using 5 training images which are represented using 100 PCA coefficient, 50% DCT coefficient, LBP 3 x 3 neighbourhood, and Weighted Sum Fusion rule. The implementation of proposed method using Weighted Sum Rule fusion produced the best performance in terms of recognition.

CHAPTER 1 : INTRODUCTION

1.1 Overview

Biometric technology has become a high demand system in today community for its capabilities in identification due to its high effectiveness and reliability. Biometric identification should be a system fill with an automated process because of the large size of data being processed to produce a biometric templates whereas using manual process is not an option because of it undesirable and time consuming (Aqmar, Fujihara et al. 2014). Biometric identification method can be categorize into two types of characteristics which is the first one is physiological and the other is behavioural (Choudhury and Tjahjadi 2013).

Physiological characteristics are based on physical appearance of body parts. It consists of palm print, fingerprint, hand structure, iris and face while behavioural characteristics are based on actions performed by humans which is it consist a certain pattern depending to subjects and this includes gait, hand signature, and speech (Bhattacharyya, Ranjan et al. 2009). Figure 1.1 display several existing biometric traits that have been used for recognition methods. Both characteristics have unique information about a person and very suitable to apply in identification process. Since born, there are biometrics that have long-lasting discriminant features such as iris, palmprint and fingerprint, which is the main part of body to recognize people using biometric identification. However, classic type of identification approach likes identity card, PIN and passwords are inadequate of meeting human demand. This is because human might lose or forget them easily.

Various biometric data can be utilized in several practical applications, for an example access control in restricted areas, criminal evidence gathering, cars control, smart homes, bank access to main money storage or office and handicapped help systems. From these examples, it is shown that, technology based on biometric has been developed in this era for more decent in identification and verification. The uniqueness of gait pattern makes it one of the dependable behavioural biometric traits compare to the other biometric traits.

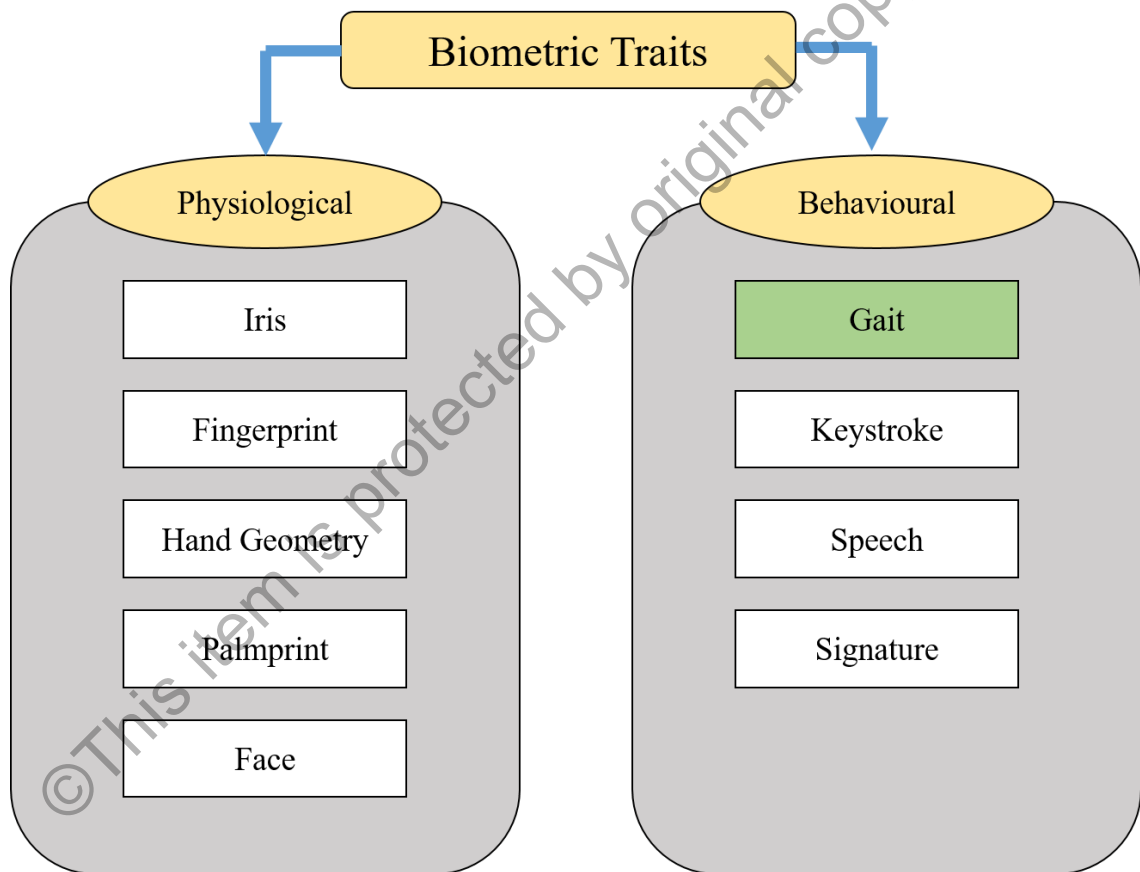


Figure 1.1 Types of Biometric Traits (Bhattacharyya, Ranjan et al. 2009)

1.2 Introduction to Gait Recognition System

Gait recognition is the technique of recognizing specific human by their gait or walking style. Gait is able to be captured at a near or far ranged using low-resolution devices, whereas other biometric methods required capturing image closely and high-resolution sensors. Gait is difficult to copy and capturing gait information is required no expensive equipment (Kusakunniran, Wu et al. 2012). Gait recognition has become one of the technologies for identifying a person's identity at a long distance. Gait recognition has turn into important category in computer vision and can be adopted in various high security places such as airports, banks, military bases, and railway stations. Apart from enabling police officers to identify criminals, gait recognition also assists in anti-terrorist operations to enhance the automatic protection of all types of locations (Su, Liao et al. 2009).

The three basic approaches used for gait recognition (Kaur and Aujla 2014) are motion-based gait recognition, floor sensor-based gait recognition and wearable sensor-based gait recognition. In the vision-based gait recognition method, gait motion is captured from a distance using a video camera. The gait features are then extracted using image processing techniques. In the floor sensor-based gait recognition method, a collection of floor sensors or force plates are equipped to measure gait features such as a maximum time value of heel strike or maximum amplitude value of the heel strike when subjects walk on these sensors. In wearable sensor-based gait recognition, gait motion is captured utilizing worn motion-recording sensors. These sensors can be used on subject's body at various locations. Gait features are recorded by the motion recording sensors.

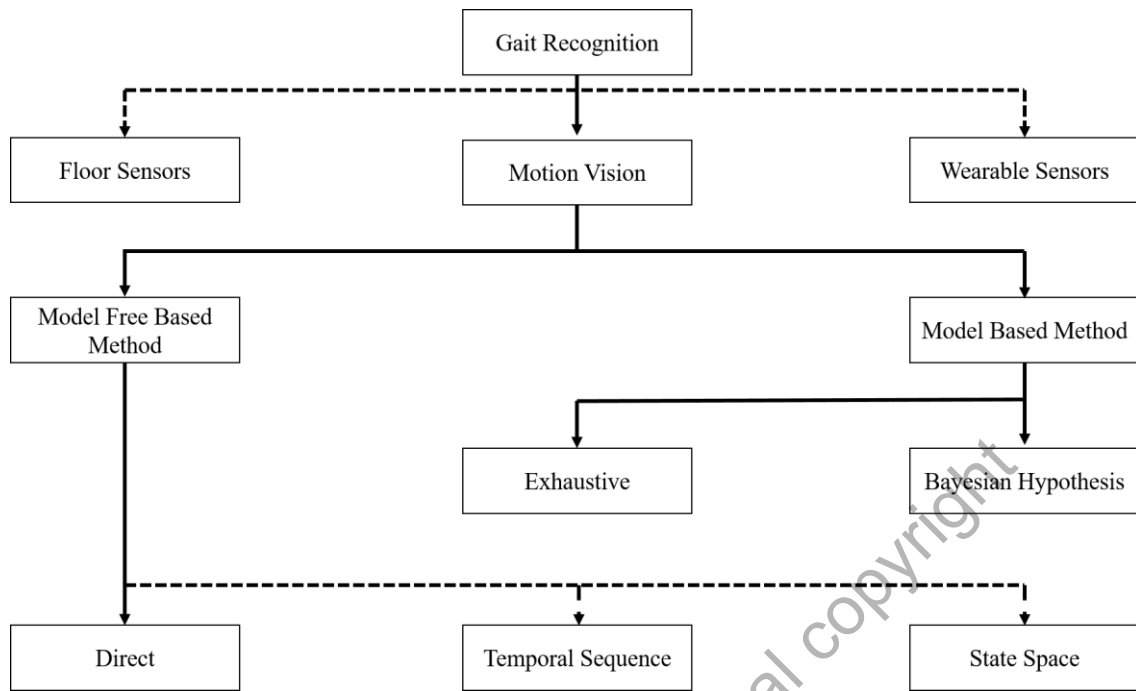


Figure 1.2 Gait Recognition Main Approaches(Shirke et al., 2014)

Over the past years, researchers have developed several motions vision-based gait recognition algorithms that classified into a couple of main techniques. The first one is model-based technique and the others is model free-based approach. Figure 1.2 shows the model-based approach that considers each human as a subject described via different body postures. It is used to model the structure of the human body based on 2D fronto-parallel body models. Gait model parameters are found in the solution space by matching the region-based information. Two searching methods are used to identify parameters, namely, exhaustive and Bayesian hypothesis. The parameters can be estimated directly or through feature extraction techniques (Lu, Wang et al. 2009). Model-based algorithms are less sensitive to noise because of shadow and clothes.

The model-free based gait recognition approach, which is used in this study, represents each human as a full-body subject using silhouettes or contours and considers the human gait as a holistic pattern (Wang, Gong et al. 2016). Most existing algorithms

used in gait recognition are model-free based methods based on silhouettes. Average silhouettes are also used by these algorithms as a gait representation technique. Three searching methods are used to identify parameters which are state space model method, direct method, and similarity of temporal sequence method (Shirke, Pawar et al. 2014).

In a biometric system, feature extraction play an important role for identification and recognition purpose. Feature extraction technique in biometric is used to extract and discriminate features in result to achieve a good result. Feature extraction is applied on biometric image after the image going through image pre-processing. Some of the image is good enough to provide all the important information but in other case some of the image required subject cooperation in order to eliminate the noise or any unwanted information (Kumar and Bhatia 2014). Based in this situation, feature extraction is divided into two categories which is local feature extraction approach and holistic feature extraction approach. Local feature extraction approach works by finding the peculiar tight features in an image that are capable of avoiding any interference (Soltanpour, Boufama et al. 2017). Meanwhile, holistic feature extraction approach extract essential features by directly apply to the whole image (Kochhar, Gupta et al. 2012). In this work, local feature extraction and holistic feature extraction will be fused using suitable fusion rule.

1.3 Problem Statement

It would be great to analyse an unconstrained gait image using holistic feature extraction while constrained gait image via local feature extraction. Constrained gait image is meant by any gait image that have noise or any unwanted signal or unnecessary information. Whereas unconstrained gait image is having only prominent signal that will

be very helpful for feature extraction phase and contain very less noise. However, each feature extraction has their own strength and weaknesses. As an example, holistic feature extraction is well known in gait recognition because of its capabilities to capture information of gait energy image. For an instance, Discrete Cosine transform (DCT) is immensely applied in the texture analysis of 2D images as well as in image compression (Su, Huang et al. 2006). DCT also decreases the redundant information in the input data by omitting the undesired parts of the data. Besides, gait energy image is an average gait image which is not complicated and sufficient to provide all the information required. Ironically, not all information in holistic features gait energy image is substantial because holistic capture all the information. Therefore, local feature extraction is needed to cater the consequences by filtering out unnecessary information. For an example, Local Binary Pattern (LBP) presents quite good performance in gait recognition (Kellokumpu, Zhao et al. 2009, Abdolahi and Gheissari 2012, Hu, Wang et al. 2013). LBP operator is originally implemented for texture describer and it is the addition of the local design in an image by distinguishing every pixel and its neighbourhood. As aforementioned, gait energy image is not too complicated, so local feature extraction is sometimes might not be helpful enough to achieve high recognition.

Both local and holistic feature extraction are required by each other in order to achieve high recognition rate. Information fusion at matching score level by integrating matching score from two different features will give a benefit to the class separation in the feature space. The matching score is generated by a metric based on the similarities between the example in the input of the biometric system and the training samples (Bayram and Bolat 2018). In this research, we will propose a fusion rule to perform this task at matching score level.

In order to do the analysis, gait database is needed for recognition rates performance. Gait database is used from a standard database that are frequent used by others researcher. Popular gait database such as CASIA can be a platform to compare the result for the proposed algorithm with other analysis.

1.4 Objectives

The objectives of this project are as follows:

1. To develop new feature extraction method for gait image using holistic and local feature extraction approach.
2. To improve class separation by using fusion rule at matching score level to integrate the similarity score from local and holistic features.
3. To evaluate the performance of the propose method in terms of recognition rates using CASIA benchmark gait datasets.

1.5 Scopes

This project will focus on the algorithm development of gait recognition system based on MATLAB software design using .m code. Two important stages will be focused in this study. The first one is feature extraction of local and holistic. Local binary pattern will be used as local feature extraction and discrete cosine transformation is issued as holistic feature extraction. The second stage is information fusion at matching score level of both methods. Both methods are fused by using fusion of sum rule and weighted sum rule. The system will be tested with a benchmark CASIA dataset to evaluate the influence of the proposed technique in terms of recognition rates.

1.6 Thesis Contribution

The proposed technique generally designs gait recognition employing holistic and local features using fusion in gait energy images. The system is tested using the CASIA dataset which contains 100 persons.

Different image pre-processing techniques are used, such as image segmentation, image normalization, and averaged silhouette representation. Each technique is applied on the gait image to improve image quality. The pre-processing techniques are applied to increase the method recognition percentage.

Two feature extraction techniques are employed, such as holistic and local feature extraction. Holistic feature extraction using Discrete Cosine transform (DCT) while local feature extraction using Local Binary Pattern (LBP). Low dimensional gait features extracted from the linear projection technique is used for the recognition process. In this process, PCA is a statistical projection technique used for gait recognition. PCA is used for dimensional reduction, which can solve dimensional problems.

A distance classifier is used for the classification. Euclidean distance is used to calculate the difference between two vectors in the feature space. The distance value between the two images measures the similarity of both images. Euclidean distance is used to measure the distances from the probed feature image to the reference feature image in the template. The two images are similar when the distance between them is minimal. Overall system performance is tested using the benchmark CASIA gait dataset.

1.7 Thesis Organization

This thesis comes with five chapters and the contents of each chapter are describe as follows.

Chapter 1 is an overview of the project is briefly explained, and problem statement, objectives and project scopes are also clearly stated in this chapter.

Chapter 2 is literature review. Explain details about previous work on gait recognition. In this chapter, pre-processing methods are briefly discussed. Feature extraction and dimension reduction are discussed. Besides, distance measurement method is also discussed. Finally, a study of existing work in the areas of gait recognition is discuss.

Chapter 3 use to describe all techniques that has been applied throughout this project. This chapter also includes gait recognition rate where this part later will become highlight of this project.

Chapter 4 contains all description to the experimental setup and shows the results of implementing the proposed algorithm using different parameters and platforms.

Chapter 5 where conclusions to the research findings with recommendations for future work. In this chapter, an overall conclusion and future work to improve performance of gait recognition is briefly explained.

CHAPTER 2 : LITERATURE REVIEW

2.1 Overview

This chapter aims to provide basic information about the project. The chapter starts by introducing the model based and model free based approach, features extraction, linear projection method, classifier design based on minimum score value and fusion based approach. These terms will be discussed as how it related with the project.

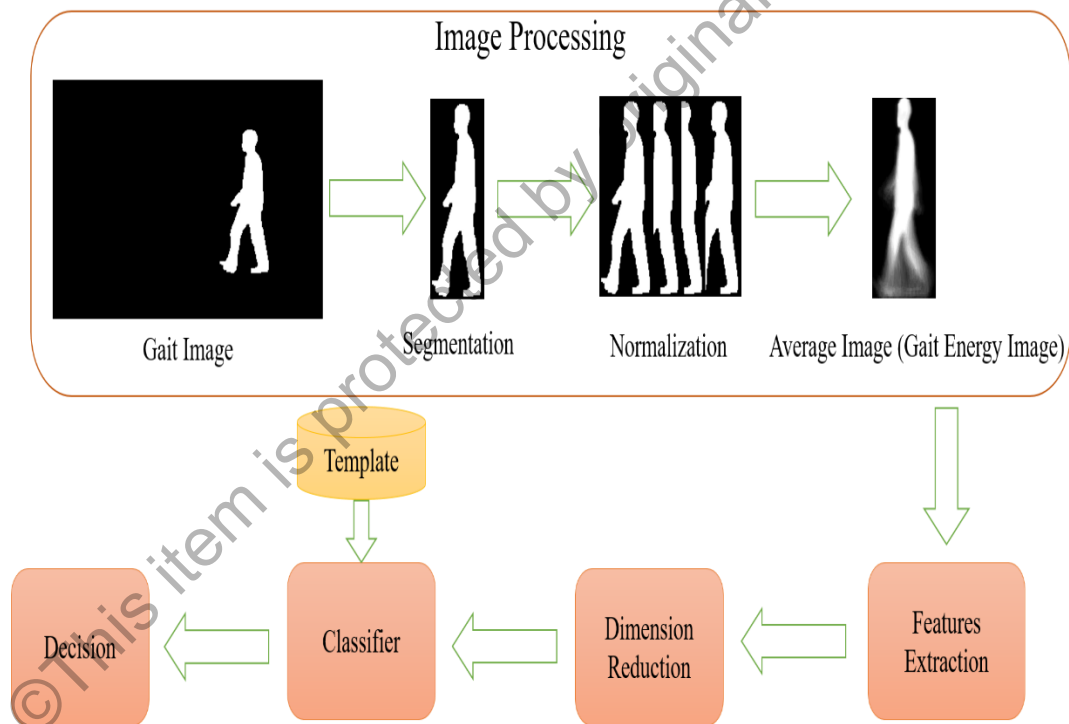


Figure 2.1 Overview of Gait Recognition System

In the gait recognition framework, the gait sequence is extracted to capture the underlying information. Each gait image will undergo pre-processing stage, such as segmentation, normalization and obtaining gait average image.

Each average image will undergo feature extraction process that involve holistic and local feature extraction. The extracted features from a gait sequence have high dimensionality because of the existing redundant and noise information in this feature. This problem is called under sample problem, so dimension reduction are required to extract only useful information.

A classification technique is applied on the gait features after dimensionality reduction, which is the second last phase of the gait recognition process before decision. Figure 2.1 shows an overall gait recognition system.

2.2 Model Based Technique

Model based technique contains a collection of dynamic and static body criterion by means of modelling or tracing a body segments such as legs, thigh, limbs, and arms (Pla, Mordvanyuk et al. 2017). Gait signatures acquired from the body criterion are then utilized to get a recognition and identification of a person. The model-based technique is view-invariant and scale-invariant (Portillo-Portillo, Leyva et al. 2017). Both, reference sequence and test sequence cannot share the similar viewpoint. Therefore, these benefits are impressive for any realistic applications. This is because, reference sequences and test sequences cannot be captured form the similar viewpoint. However, high quality image for gait is required to acquire a great accuracy result. This is because, model-based technique is sensitive to condition of gait sequence. In addition, model-based technique is time consuming and required large computational as a result to complex parameters calculation compared to model free technique.