Gender Identification System in Women-Only Parking Lots by Using Gait Analysis

by

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14867

Dissertation submitted in partial fulfillment of

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CERTIFICATION OF APPROVAL

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Approved by,

____

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(ZULFAIZ BIN ZULHASNI)

ABSTRACT

There are a lot of problems faced in parking lots where the safety of women is insecure due to dark and quiet environment. Security personnel requires high cost and they tend to make errors or overlooked. Thus, a gender identification system was proposed to solve the matter. Human gait as a method of human recognition is not new in biometrics systems nowadays. In this project human gait is used for gender identification because of its advantages in this particular application, Gender Identification System in Women-only Parking Lots. One major advantage of this identifier compared to others is it does not require the person's attention or cooperation. Furthermore, gender identification using gait analysis can be achieved even when the person is far away. In this project, images are obtained from a publicly available dataset, Class B CASIA Gait Dataset. The scope of this project is based on the dataset itself where each image sequence are offline images of only one person wearing only tops and pants. These images are taken from a video that is recorded with frame rate of 25 frames per second at a 90 degrees angle from the direction of the person. The images which are obtained from the video are then converted into silhouette through background subtraction. Then features are extracted from the silhouette dataset. These two extraction process are very important pre-processing methods in a gait identification system. From the results shown, silhouettes were extracted by a good selection of threshold value. Four features were achieved from the silhouette images which were height, weight, area, Gait Energy Image (GEI). In addition, 56 more features were added resulting to 60 features in total. Lastly, a classifier is used to classify these subjects into its respective group, male or female. The results obtained an accuracy of 77.5% by using K-Nearest Neighbour (KNN) Classifier.

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CHAPTER 1: INTRODUCTION

1.1 Background

Authentication Systems are growing in demand in this modern world. Personal identification such as MyKad is compulsory to all Malaysian citizens aged 12 and above. Personal identification is very important because it has a wide range of applications and the main application is security. It contains the biometrics data of an individual so that biometric identifiers can detect and describe the individual. Biometric identifiers are divided into two categories namely physiological and behavioural characteristics. A physiological biometric is described by the scientific study of an individual. Examples of physiological biometrics are an individual's voice, DNA, or finger print. Behavioural biometric on the other hand identifies the behaviour of an individual, such as typing rhythm, hand gesture or human gait which is the focus of this project.

Women's safety and security is a major concern in Malaysia. Many actions have been taken to ensure this. Over the past decade, Malaysia has introduced facilities specifically designed for women or 'women-only' facilities. One of them is the women-only commuter coach operated by Keretapi Tanah Melayu (KTMB). Another facility includes women-only customer lanes in supermarkets nationwide. Recently, women-only parking zones are provided by one of the most popular shopping complex in Malaysia, Suria KLCC. This is to ensure that the safety of all the women is secured, especially in parking zones which are often quiet and dark. These parking zones are equipped with several CCTVs and monitored by security personnel to ensure that no men can access these areas. The zone is monitored by security personnel to ensure everything goes right. Another alternative is to implement a gender identification system which could trigger the alarm if there are men who try to access the areas.

1.2 Problem Statement

A gender identification system is not easy to be implemented. It has to be effective and reliable to ensure that it does not make any errors. There are a few factors that affect the performance of the system. The environment changes from time to time in terms of the lighting and noise. In the afternoon the environment is much brighter than at night and this may cause the system to be unreliable. The noise is loud when there are a lot of people around the area and this will affect the system if it uses voice recognition. A good camera is needed to ensure that the details of a person can be extracted properly for further analysis.

Therefore a system must be robust enough to ensure the problems are overcome. It requires careful thought and analysis to ensure that the system is applicable and solves all the problems with minimal or without errors.

1.3 Objectives

The objectives of this project are as follows:

i. To design a gender identification system using MATLAB

ii. To evaluate and analyze the performance of the system using existing dataset

1.4 Scope of Study

The scope of the work are as follows:

i. Offline test images are used, no real time implementation of the system

ii. Each image contains one person

iii. The person in the image is based on one camera angle that is 90 degrees

iv. The person’s clothing is restricted to tops and pants only

v. The system is software based using MATLAB only

CHAPTER 2: LITERATURE REVIEW

2.1 Overview

There are many studies on gender identification with different methods of identification. None of the studies claim or prove that their proposed method are the best method. Obviously, this is because the applications are different and no method achieved 100% accuracy. Therefore there is a great need to perform this study especially when there are many applications that require this system.

The chapter covers most of the commonly used methods in gender identification systems. Every system has its own advantages and disadvantages. Voice recognition, face identification and gait recognition show excellent results with error rate of less than 20% in [1][2][3][4]. However, not all gender identification systems are suitable to be implemented in women-only parking lots due to lighting conditions, space area for the monitoring and camera quality which affects the cost of the system. After considering all of these external factors, human gait was chosen to be the method of the gender identification system.

2.2 Gait Analysis

Gait is the way human beings or animals move on foot, whether it is running or walking. The gait of most animals is quadrupedalism where the animal moves by all four of its legs. Human moves by its two legs and therefore called bipedalism. A different gait pattern means a different way of walking or running which are actually the same as difference in velocity, forces, patterns, and change in contact with the floor. A gait can be changed naturally by age and body weight. It could also be changed when a person trains to walk and run differently.

Gait recognition has many characteristics that other gender identification methods do not possess. The best characteristic that makes it suitable for gender identification in women-only parking lots is it is unnoticeable. This means that the system is able to monitor an individual without his or her knowledge and cooperation. Voice recognition requires the voice of the speaker to implement certain speech processing techniques to obtain the vocal fold thickness and the vocal tract length [5]. Therefore the implementation of voice recognition is very difficult in this case.

At the very same time, the system does not obtain private information of the individual compared to other systems such as face recognition which could raise privacy concerns [6][7]. In addition, a human gait can still be obtained if the person is far away. This is a great advantage as parking lots are big space areas. Apart from that, gait recognition does not require high quality videos with high resolution compared to face identification which requires high pixels to obtain the necessary information to define the individual [8].

In anything, there are always advantages and disadvantages. The disadvantage of gait compared to other systems is that the way and manner of moving can be easily changed intentionally or unintentionally. Intentionally, a man with training can imitate the way a woman walks and he can also change his walking style to something that the system cannot identify. Despite that, the public does not know what type of identifier the system is using because the security methods are always confidential. Therefore, no men will purposely imitate a gait or change his walking style. Apart from that, walking style of an individual changes due to the increase or decrease of body weight [9]. Accidents and aging also might affect the gait of an individual. However all of this does not matter as long as the system is robust.

Most of the gait related projects use a publicly available gait dataset due to its efficiency. This is to compare and analyze the performance of the gait recognition patterns fairly. These projects do not use a new dataset because creating it is troublesome and wastes a lot of time. Apart from that, a large amount of volunteers are required to create a robust dataset. Reducing the amount of subjects will only result in a small and unreliable dataset. There are also other external factors to be considered such as lighting and big space area for video shooting. A good video recorder specification is also needed for the shooting. Therefore, publicly available gait dataset was used.

2.3 Publicly Available Dataset

There are quite a number of gait dataset that is available for public but the top 3 among them are University of South Florida (USF) Gait Dataset from United States of America (USA), University of Southampton (SOTON) Gait Dataset from United Kingdom, and Chinese Academy Sciences (CASIA) Gait Dataset. Further details of these three dataset are explained below.

University of South Florida (USF) Gait Dataset

The USF gait dataset is the oldest gait dataset available. Inside this dataset are files which consist of snap shots from a video file. The dataset was generated at the university itself, USF, Tampa, USA and it was collected within 4 days. (20th May 2001, 21st May 2001, 15th November 2001 and 16th November 2001). The size of the whole dataset is around 1.2 TB. Further details of the dataset can be seen in the table below:

Table 1 USF Gait Dataset Details

Description	Details
No of subjects	33 people
Shoe types	A and B
Accesories	With/without briefcase
Surface types	Grass or concrete
Viewpoints	Left and right

In this dataset, the gait of a person can be observed by 32 different ways after mixing around the above factors. However, not everyone managed to do each type of conditions. The naming convention of the gait dataset can be seen in the Figure 1 below.

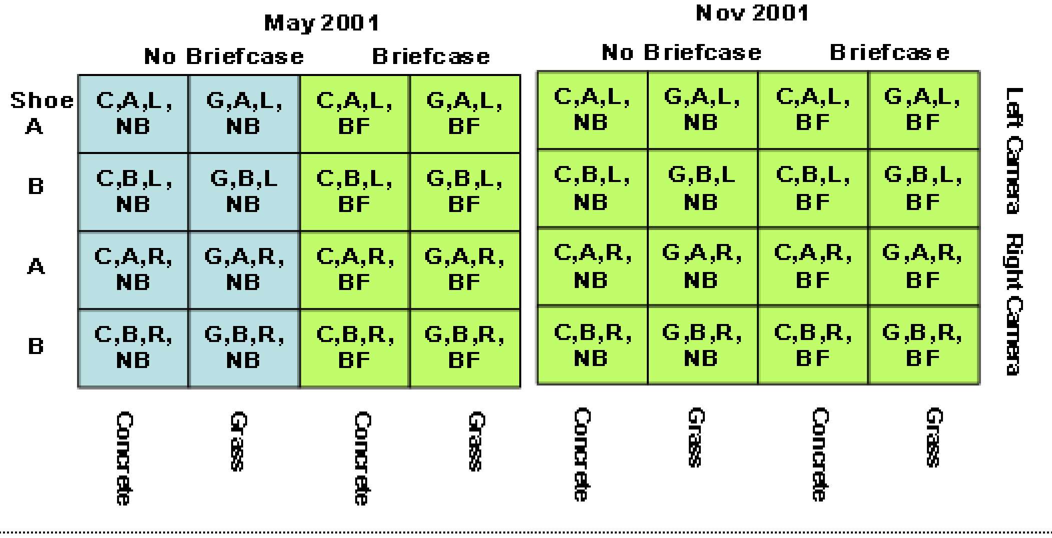

Figure 1: Naming convention in USF Gait Dataset

The blue boxes represent the data of the people with no briefcase on May 2001. Otherwise, they represent the data of the people with briefcase on May 2001. However, as for the data obtained on November 2001, no colour coding had been shown.

Figure 2 below shows a sample picture taken from the USF Gait Dataset.

Figure 2: A sample picture taken from the dataset

University of Southampton (SOTON) Gait Dataset

There are two separate folders for the SOTON Gait Dataset. Each folder has its very own use. The first folder contains a very large database which consists of approximately 100 subjects. The second folder contains fewer subjects but has more details. The first folder is for researchers with the intention of analysing a human gait at normal conditions only. It could also be used to analyse the behavioural biometrics for image processing and extraction process. The second folder on the other hand is for researchers who plan to investigate the capability and robustness of the dataset to the extent of having different conditions such as different types of body accessories and clothing.

Chinese Academy of Sciences (CASIA) Gait Dataset

There are 4 Datasets in this huge CASIA Gait Dataset named Dataset A, Dataset B, Dataset C and Dataset D. Dataset B contains the highest number of subjects which is 124 people unevenly distributed, approximately 30 females and 100 males.

The oldest dataset is Dataset A, generated on 10th December 2001. There are 20 subjects and 3 camera angles which are 0 degree (parallel), 45 degrees and 90 degrees to the direction of movement. There are approximately 12 gait cycles for each subject, and 4 cycles for each camera angle. The advantage of this dataset is that it also contains the silhouette dataset of each subject. The size for dataset A only is around 2.2 GB. Figure 3 below shows some samples obtained from Dataset A where each image has a different camera angle.

Figure 3: Samples from Dataset A with different camera angle

The second dataset, Dataset B which has the largest size of around 10 GB, is a multi-angle dataset which was generated in January 2005, approximately 3 years after Dataset A was generated. As mentioned previously, it contains 124 subjects and has 11 different camera angles. Apart from that, it has different conditions such as clothing type and carrying condition. A person is either wearing a coat or not, and either carrying a briefcase or not. Figure 4 below shows some samples obtained from Dataset B.

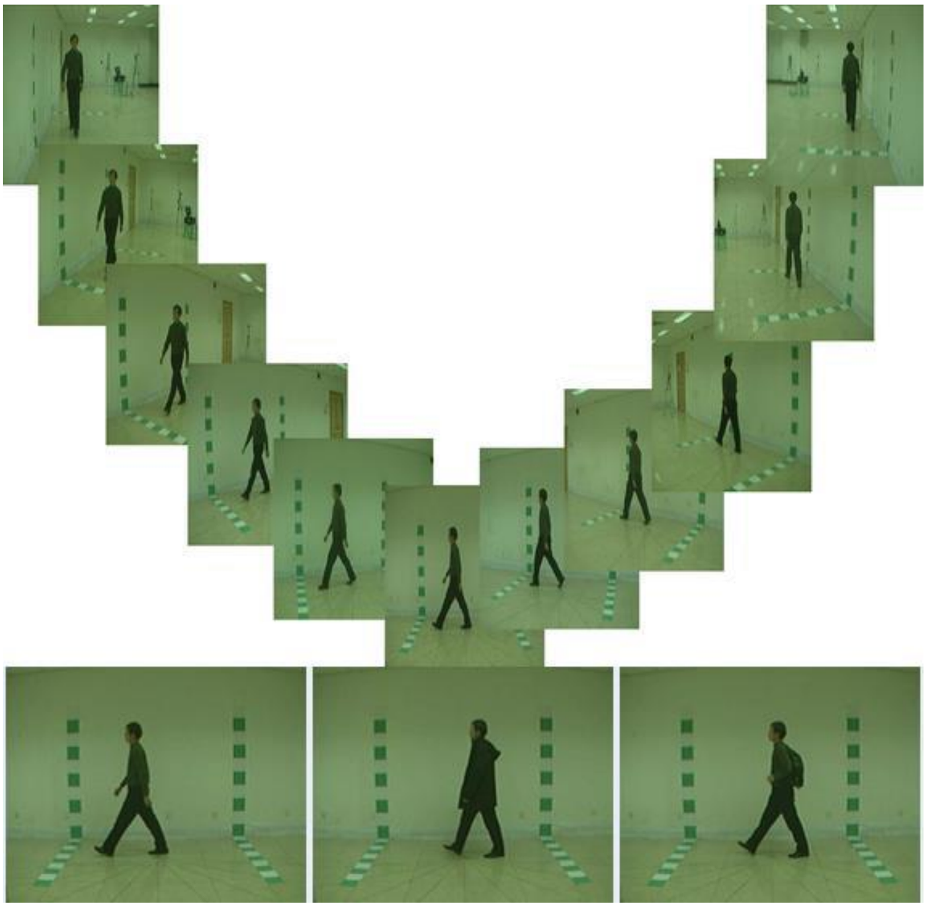

Figure 4: Samples from Dataset B

The third dataset, Dataset C is unique. It was generated over 2 months (July 2005-August 2005) and was taken from an infrared camera. Furthermore, they were generated at night. The dataset contains 153 subjects with different conditions namely:

i. Normal walking without a bag
ii. Normal walking with a bag
iii. Slow walking
iv. Fast walking

Figure 5 shows samples taken from the dataset.

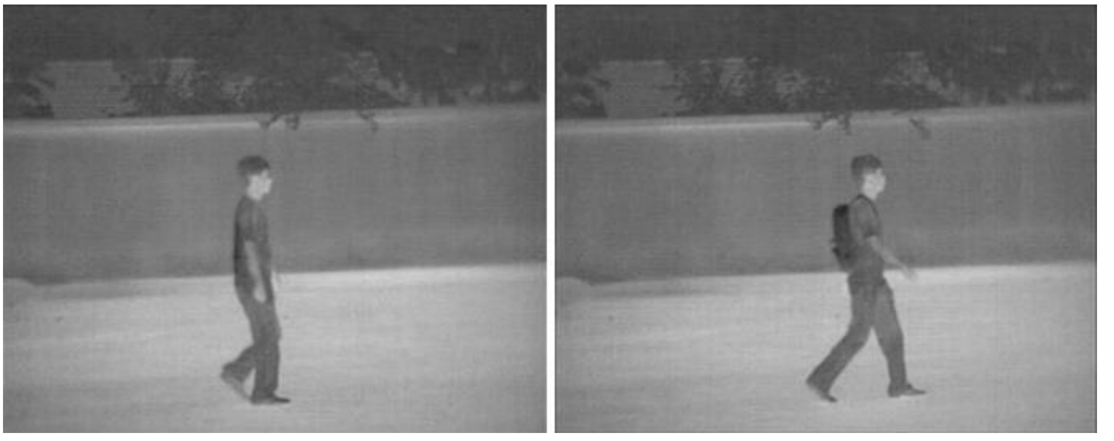

Figure 5: Samples from Dataset C

Dataset D focuses on real life situation where it took into account real surveillance situation where video cameras were normally attached above the person either on the ceiling of high above the wall. The dataset was generated within 2 months (July 2009-August 2009) and contains 88 subjects. Figure 6 below shows samples obtained from Dataset D.

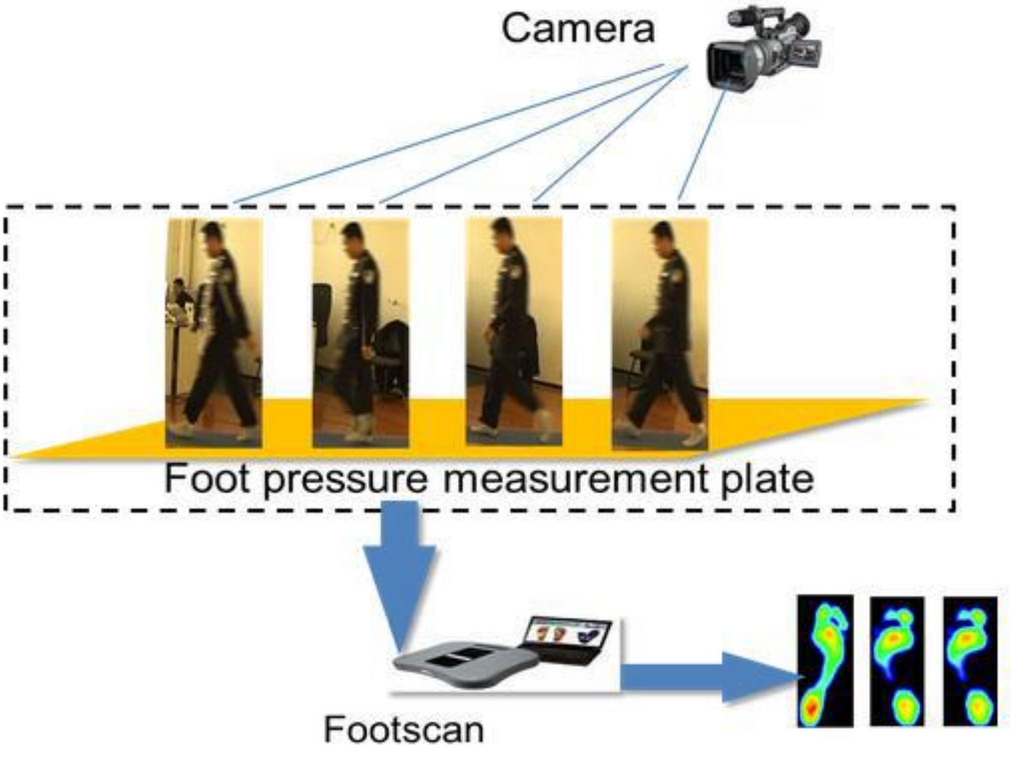

Figure 6: Samples from Dataset D

Below is the table of CASIA gait video specification

Table 2: Casia Gait Video Specification

No	Description	Details
1.	Video Format	AVI Video
2.	Length	Around 3 – 5 seconds
3.	Size	Around 1MB
4.	Resolution	320 x 240
5.	Frame Rate	25 fps
6.	Bitrate	200 kbps

2.4 Silhouette Extraction

All the studies relating to gait analysis require the extraction of the silhouettes because they are capable of providing sufficient information [16] to achieve the classification of human gender. Silhouette extraction algorithms depend on a known background [17]. The background image is taken when the subject is not in the picture and a simple method to obtain this silhouette is called background subtraction. It is a technique which is very common in image processing where an image's foreground is extracted for further processing. Generally an image's foreground are objects such as humans or animals, often called the subject. The background subtraction technique is widely used to obtain moving objects from videos where the camera is placed static. The approach detects the moving objects from the difference between the current image and a reference frame which is also the background image [18]. However image thresholding is still needed to improve the quality of the extracted image and turn it into a silhouette image.

2.5 Feature Extraction

There are plenty of features which can be extracted from a silhouette image. In [19], they used free model-based for spatial data extraction and model-based for temporal data extraction. For the free model-based, Gait Energy Image (GEI) is used as a feature. It is stated that this feature is the best feature extraction method for gait recognition and classification up till now [3][7]. The advantage of GEI compared to other feature is that it represents all the silhouettes from the video file into a new energy image. Furthermore it has smoothening effect and removes noise.

In another paper [17], the centre of mass of human body is used as a feature. The centre of mass of human body changes from one instance to another as a person walks. Provided a binary image, *B*, the centre of mass can be achieved using the following formula:

$$\bar{x} = \frac{\sum_{i=0}^{n} \sum_{j=0}^{m} j * B(i,j)}{A}$$

$$\bar{y} = \frac{\sum_{i=0}^{n} \sum_{j=0}^{m} i * B(i,j)}{A}$$

Where $\bar{x}$ and $\bar{y}$ are represents the coordinates of the centre of mass in the image. m and n are the size of the image in matrix pixels. *A* is the area of the white points in a binary image.

$$A = \sum_{i-0}^{n} \sum_{j=0}^{m} B(i,j)$$

The height of a person can determine whether it is a male or female because generally, men are taller than women. Therefore height is an important feature that differentiates a male and a female.

An interesting paper [15], the silhouette obtained is divided into 7 regions where each region covers different parts of the body as illustrated in Figure 7 below.

Figure 7 Silhoutte Regionalization

Then an ellipse is fitted to each region according to the shape of the foreground pixels as shown in Figure 8.

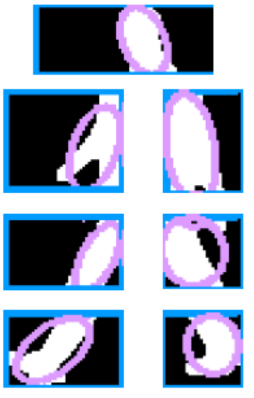

Figure 8 Ellipse Fitting

There are four features which are extracted from each ellipse namely the centroid, length of major axis, length of minor axis and the angle of orientation. The gait sequence is then represented by the mean and standard deviation of all the parameters of each ellipse where the mean is defined as the average of all the numbers. Meanwhile, standard deviation is the average grey value within the image. It can also be explained as the sum of grey values of all the pixels divided by the number of pixels. Obtaining the mean and standard deviation will result in 8 features for each ellipse or region which sums up to a total of 56 features.

Classification is the process in which objects or images are differentiated, categorized or classed to be identified and known. Although it may seem look very easy for humans, it doesn’t work the same for machines. Instead it is a very difficult task and problem for machines. When talking about classifiers, all classification algorithms are the same where they come up with the results after assuming that the unknown image satisfies with at least one feature and that each of these features sits among one of several distinct and exclusive classes. The effort in designing and implementing automatic image classification algorithms has been an important research field for decades.

Usually classification is done in two phases of processing. One is called training and the other is called testing. The training process starts first where this is the time for the computer to learn the features. In this initial training phase, characteristic properties of typical image features are isolated and based on these, a unique description of each classification category, that is the training class, is created. In the following phase, the testing phase, features are identified and these feature-space partitions are compared to determine the class of each image.

Training class plays a very important part in the classification process. The major components in creating a good training class is that they are independent, discriminatory and reliable.

Independent is described as a change in the description of one training class should not change the description of other classes. Discriminatory is when different image features have a very clear difference in their description and reliable in terms of all image features within a training group share the common definitive descriptions of that particular group.

In many cases, classification will be undertaken using a computer, with the use of mathematical classification techniques. Classification is done according to the following procedures:

In most cases, a computer does all the work of classification by using computational and mathematical techniques. There are a few procedures that have to be followed in order to achieve a successful machine learning algorithm.

1. Classification Classes Definition

   The definition of classification classes should be easy to perceive.

2. Feature Selection

   There are two types of characteristics for features to distinguish between each classes namely multi-spectral or multi-temporal.
3. Taking Sample for Training Data

   These step is done to identify the best decision rules. The classification of unknown objects using the classification will be merely based on the training data.
4. Comparing other Machine Learning Algorithms

   There is a wide range of classification techniques which will be compared with the training data to achieve the most suitable decision rule for the selected classifier.
5. Classification

The pixels are classified in a single class depending upon the decision rule.

6. Results Verification

   Results should then be verified for its precision, accuracy and reliability.

It is known that two of the most popular classifiers are K-Nearest Neighbour (KNN) and Sequential Minimal Optimization (SMO).

2.6 Classifier

K-Nearest Neighbour (KNN)

KNN is the simplest, easiest and the most widely used classifier. The name itself tells how an object is classified. An object will be assigned to the class where its closest neighbour is in. That is if the parameter value $k=1$. That is why the nearest neighbour's class is simply taken to be classified to the object [21]. Distance is an important tool in this algorithm where each object is located in the position vectors in a multidimensional space. The Euclidean distance or also used to known as Pythagorean distance is the term used to measure the distance between two objects in a multidimensional space.

The value chosen for *k* must not be the multiples of the number of classes. For example, in a two-class classification, *k* must not be the value of 2 or multiples of two to avoid any ties. Apart from that, an important thing in using KNN classifier is the value to be used for *k*. The value of *k* for this algorithm must be suitable to achieve accurate results. A rule of thumb is to select the square root of the total data available. According to [22], the larger the value of *k*, the less effect of noise on the classification. However, the class boundaries will no longer be precise. Therefore choosing the best value for *k* is very important to make the classification a success.

CHAPTER 3: METHODOLOGY/PROJECT WORK

3.1 Tools and Software Used

This is a software based project therefore there are no hardware tools required.

i. CASIA Gait Dataset

ii. MATLAB Software

3.2 Approach

3.2.1 Overview

Figure 9 shows the flow chart of the project methodology. In order to start implementing a system, an input is required and in this case, a gait sequence image is required. The images can be attained by capturing images from a video of a walking person. However this is time consuming and the plan of this project was to attain as many subjects possible to make sure the results are acceptable. Therefore like most of the other gait researchers, the same gait dataset which is available for public was to be used in their project. This will also improve the project's efficiency [9] and make comparisons easily. For this project, the Chinese Academy of Sciences (CASIA) Gait Dataset is selected to conduct all the experiments. This is because the dataset meets the requirements of this project. Those requirements can be seen in the project scope section and also further on in this chapter.

3.2.2 Silhouette Extraction

After filling up the agreement to obtain the dataset, the image processing can be done to obtain the required information. The project started with the pre-processing which includes the silhouette extraction through background subtraction and setting a threshold in a way similar to the approach in [11][12]. The background subtraction is done by obtaining the background image with no subject in it. Then, the background image was then subtracted by the captured images obtained from the video. All the images were then converted to black and white images. A shadow of the walking person can later be seen. Implementing a threshold will then improve the image quality and a silhouette will appear. The whole process of silhouette extraction is shown in the following code:

```
%*******************SILHOUETTE EXTRACTION USING BACKGROUND SUBTRACTION
background = 'F:\CASIA Gait Dataset\DatasetB\snaps\snap0\1.png';
BG = imread(background);
grayimagee = rgb2gray(imagee);
grayBG = rgb2gray(BG);
diffImage = abs(double(grayimagee) - double(grayBG));
binaryImage = diffImage > 25; %example threshold value
```

Figure 9 Silhouette Extraction Code

3.2.3 Feature Extraction

It was continued with the process of feature extraction.

In order to extract features from the image, only certain type of features which could help in the classification process were selected. Therefore, more research needs to be done before the feature extraction process was started. From the literature reviews done, the ones that were suitable, achievable and reliable features were selected to be studied and implemented. The chosen features were height, width and area. The feature extraction for height width and area is shown in the following code:

```
%****************************************************FEATURE EXTRACTION
%FEATURES - %height, width and area calculation
[r,c] = find(binaryImage);
x2 = max(c);
x1 = min(c);
Width = x2 - x1;
width(row,1)=Width; %Feature #1
y2 = max(r);
y1 = min(r);
Height = y2 - y1;
height(row,1)=Height; %Feature #2
Area = bwarea(binaryImage);
area(row,1)=Area; %Feature #3
```

Figure 10 Feature Extraction Code

Apart from that, Gait Energy Image (GEI) was obtained and used as a feature by using the formula proposed in [13],[14]. The GEI is defined as:

$$F(i,j) = \frac{1}{T}\sum_{t=1}^{T} I\,(i,j,t)$$

where T is the number of frames in the sequence $I(i,j)$, $I(i,j,t)$ is a binary silhouette image at frame t, i, and j are the pixel coordinates. The code to obtain the GEI is shown in the code below:

```
%FEATURE - Gait Energy Image/Motion (GEI)/(GEM)

% Cropping silhouettes
posX=((x1+x2)/2)-40;
posY=((y1+y2)/2)-75;
I = imcrop(binaryImage,[posX posY 80 150]);

%Gait Energy Image
sum = sum + I;
gei = sum/(length(jpgfiles));
das=im*255;
imshow(gei,[])
```

Figure 11 Gait Energy Image Code

The project was continued with the process proposed in [20]. The first step is silhouette regionalization which is done by dividing the silhouette into 7 regions which cover different parts of the body. This process is done so that the feature extraction is more specific to a certain part of the body. The next step is by fitting in an ellipse to the foreground pixels of each region. From the obtained ellipses, 4 features are extracted namely:

i. centroid
ii. length of major axis
iii. length of minor axis
iv. the angle of orientation

The above steps are done by using the code shown below:

```matlab
%FEATURE - Ellipse Fitting
s = regionprops(bw, 'Orientation', 'MajorAxisLength','MinorAxisLength', 'Centroid');
imshow(bw)
hold on
E=s(1);
phi = linspace(0,2*pi,50);
cosphi = cos(phi);
sinphi = sin(phi);

for k = 1:length(s)
    xbar = s(k).Centroid(1);
    ybar = s(k).Centroid(2);

    a = s(k).MajorAxisLength/2;
    b = s(k).MinorAxisLength/2;

    theta = pi*s(k).Orientation/180;
    R = [ cos(theta)   sin(theta)
         -sin(theta)   cos(theta)];

    xy = [a*cosphi; b*sinphi];
    xy = R*xy;

    x = xy(1,:) + xbar;
    y = xy(2,:) + ybar;

    plot(x,y,'r','LineWidth',2);
end
hold off
```

Figure 12 Ellipse Fitting Code

The gait sequence is then represented by the mean and standard deviation of all the parameters of each ellipse where the mean is defined as the average of all the numbers. Meanwhile, standard deviation is the average grey value within the image. It can also be explained as the sum of grey values of all the pixels divided by the number of pixels. Obtaining the mean and standard deviation will result in 8 features for each ellipse or region which sums up to a total of 56 features. These additional features will help to improve the accuracy of the system when classification is done.

3.2.4 Classification

The last important process was to determine suitable classifiers to identify different genders with the features that was chosen. In this part, much analysis were done to make sure that the classifier selected was the suitable ones for the features that are extracted. The chosen classifier was KNN Classifier. Lastly the results were recorded and analysed.

In Figure 13 below is a flow chart of how the project was performed.

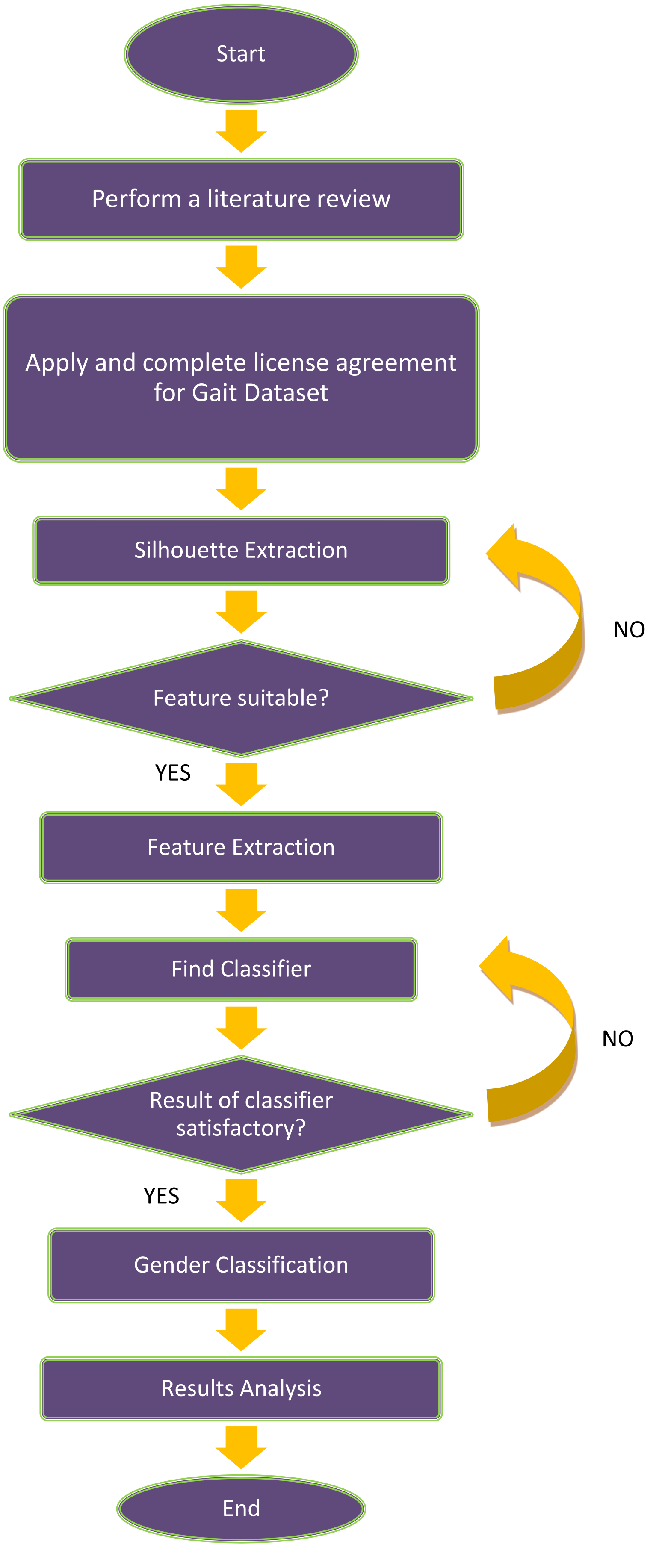

Figure 13 Flow Chart of Project Methodology

Figure 14 and Figure 15 below is the Gantt Chart for FYP I and FYP II respectively. The Gantt Chart was followed accordingly and everything was on schedule.

3.3 Gantt Chart For the Whole Final Year Project

No	Activities/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Identifying job scope, problem statement, proposed solutions. Planning of project flow. Creating a technical folder. Collecting journals.		■	■	■	■									
2	Writing and testing MATLAB code for silhouette extraction.						■	■	■						
3	Applying silhouette extraction code and save the silhouette images for further processing.									■					
4	Writing and testing MATLAB code for feature extraction.										■	■	■	■	
5	Applying feature extraction code.														■

Figure 14 Gantt Chart

No	Activities/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Finding and analyzing the classifiers that are suitable for the project.	■	■												
2	Use the selected and chosen classifiers.			■	■	■	■								
3	Results and Computational Analysis							■	■	■	■				

Figure 15 Gantt Chart for FYP II

3.4 Project Milestones

The Project Milestones of this project is shown in Figure 16 below. Listed are the milestones or major events that had been achieved during the dates listed in the same row.

Milestone	Date of Completion
Produce or obtain database	24th October 2014
Silhouette Extraction	31st October 2014
Feature Extraction	16th January 2015
Gender Classification	20th February 2015
Computational and Analysis	20th March 2015

Figure 16 Project Milestones

CHAPTER 4: RESULTS

4.1 Silhouette Extraction Process

Figures 17, 18,19 and 20 below show the process of silhouette extraction. Figure 17 shows the background image which is obtained when the subject is not in the picture. Then in Figure 18, it can be seen that a person is walking and the gait is obtained from there.

Figure 17 Background Image

Figure 18 Walking Image

Figure 19 shows the result of background subtraction between Figure 18 and Figure 17. In order to improve the silhouette quality, a threshold is implemented to obtain a clean and quality image as shown in Figure 20.

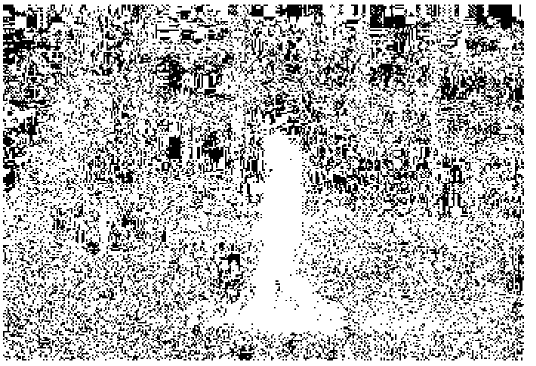

Figure 19 Image after Background Subtraction

Figure 20 Silhouette Image

A good threshold value is important to achieve a good quality image. Problems arise when the lighting conditions change. This may cause errors and the process of silhouette extraction might result in a low quality image. Figures 21, 22, 23, 24 and 25 shows the effect of different threshold to the image. In this project, the threshold value is done by visual inspection and 24 is selected as the threshold value.

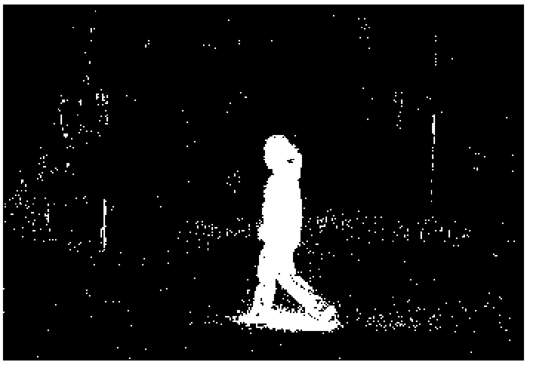

Figure 21 Threshold Value 5

Figure 22 Threshold Value 10

Figure 23 Threshold Value 15

Figure 24 Threshold Value 20

Figure 25 Threshold Value 25

4.2 Feature Extraction

4.3.1 Height, Width and Area

The silhouette is extracted therefore details can be obtained from the silhouette image shown in Figure 18. The three features that can be obtained directly are the height width and area in terms of pixel points. The details are shown in tablle below.

Features	**Value (pixels)**
Height	129
Width	65
Area	2.5505e+03

Table 2 Silhouette Details for Figure18

4.3.2 Gait Energy Image

The Gait Energy Image (GEI) represents all the silhouettes in the video file into a new energy image as shown in Figure 27.This is achieved after all the image sequences are cropped into the same size as shown in Figure 26 and the GEI formula explained in the methodology is applied.

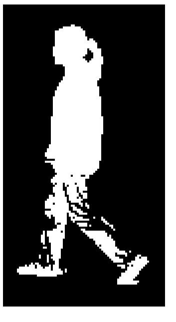

Figure 26 Cropped Image

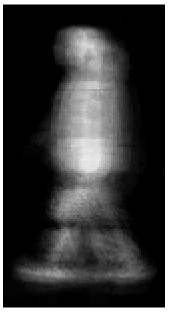

Figure 27 Gait Energy Image (GEI)

4.3.3 Centroid, Major Axis, Minor Axis and Angle of Rotation

The silhoutte is divided into 7 regions as shown in Figure 28 below. Then in each region, an ellipse is fitted to the foreground pixels of the region and this can be seen in

Figure 29. The Centroid, Major Axis, Minor Axis and Angle of Rotation are obtained from the resulting ellipse as labelled in the example of Figure 30.

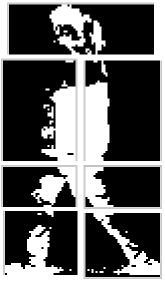

Figure 28 Seven Regions

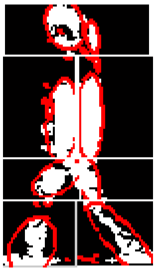

Figure 29 Fitted Ellipse

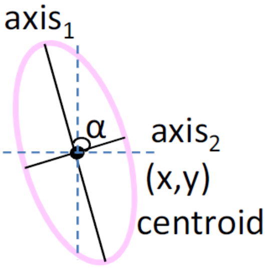

Figure 30 Ellipse

Below is the tabulation of results from the KNN classifier.

NO	DETAILS	ACCURACY
1	First attempt	37.5%
2	Removing bad silhouettes by improving threshold value	45%
3	Selecting silhouettes manually to achieve a full gait sequence	60%
4	Balancing number of male and female in training set	77.5%

Figure 31 Classifier Results

$$\text{Accuracy} = \frac{\text{correct images}}{\text{total images}} \times 100\%$$

The accuracy was obtained from the above equation.

The first attempt was not good because the accuracy was only 37.5%. After doing some analysis, it was detected that the silhouettes that were extracted were very bad where the silhouettes were not fully and smoothly showing the silhouette of the walking person. This was caused by bad thresholding technique. After the improvements were made, the silhouettes improved as what is shown in Figure 21 to Figure 25. Then the classifier was tested again and the results showed better improvements where the accuracy value was 45%.

More analysis was done to determine the cause of not achieving at least 75% accuracy. It was found that certain subject did not obtain a full gait sequence due to two reasons. Firstly, different person has different pace of walking. Secondly the time for each person to start walking from the start of the video is different. Therefore, more frames was extracted from a video to ensure that a full gait sequence of the slowest and fastest person can be obtained. After improving this, the results was much better with 60% accuracy score.

The KNN classifier was mentioned that as a rule of thumb, the k value should be set to the square root of the number of samples to achieve better accuracy. In this project the training set was not balanced between male and female. About 80% of the whole training sample was male and the rest was female. Therefore when the k value of the KNN classifier is more than 1, it created a bias. The training set was regenerated. The training set is now balanced equally between male and female. The best results obtained was after this change and the accuracy was 77.5%.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

In the human eyes, it is very easy to identify a gender of an individual through his or her gait. However, creating a system for gender identification through human gait is very complex because there are so many similarities between certain men and women. Therefore the system needs to be robust and capable to identify each and every feature of men and women. There are also other external factors which affect the capabilities of the system such as the surrounding environment and the subject's inconsistent movement. This project is able to achieve its objectives and overcome the problems faced. However the system has its weaknesses and this system did not obtain a very good result. This are due to several reasons:

i. The system is only able to work on offline images and this is a fully software based system
ii. The time taken to process the movement of a person takes some time therefore it is not ready to be implemented in real time
iii. Accuracy score is 77.5%

The project can be further improved if it is integrated with a hardware tool that has very good and fast processor for it to achieve a real time implementation. Another good recommendation is to increase more features to achieve much greater accuracy. Apart from that, if the system considers more factors apart from just the gait analysis (face and voice recognition.), then the results would be more accurate.

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