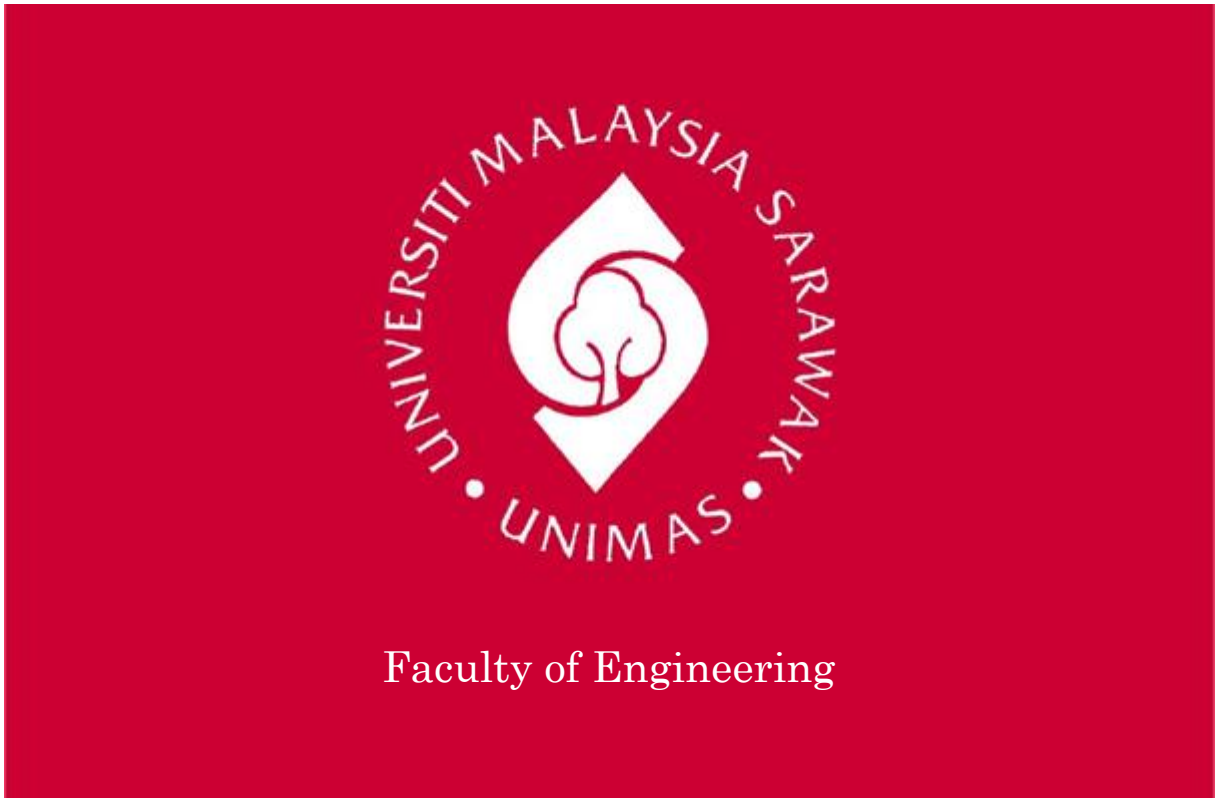

INDIVIDUAL RECOGNITION BASED ON GAIT PATTERN

Desmond Belaja Anak Dadu

Bachelor of Engineering

Electrical and Electronics Engineering with Honours

2022

UNIVERSITI MALAYSIA SARAWAK

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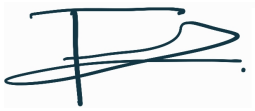
Supervisor signature:  (21/7/2022)

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Individual Recognition Based On Gait Pattern

DESMOND BELAJA ANAK DADU

A dissertation submitted in partial fulfilment
of the requirement for the degree of

Bachelor of Engineering

Electrical and Electronics Engineering with Honours

Faculty of Engineering

Universiti Malaysia Sarawak

2022

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ABSTRACT

In this project, the focus is on human biometric system. Human biometric system can be divided into two groups which is physiological and behavioral. In this project, behavioral will be used, gait to be precise. Gait by definition is manner of walk, while Gait recognition is how to identify a human by using their walking style due to each person have different walking style. Convolution Neural Network, CNNs is the proposed method used for this project to classify the image of the gait via CNN Pre-Trained Network Model and to identify which pre-trained is the best for gait recognition. Gait Energy Image of the CASIA-B dataset in lateral view or equivalent to 90˚ of walk will be used. There are 124 subjects involve for CASIA-B dataset. Pre-Trained Network will be used to classify them. The main function of this Pre-trained Network is to classify each image and for feature extraction. There are a lot of pre-trained network that available out there, different pre-trained network will lead to different accuracy. As they have their own accuracy and speed for the image classification. In this project, MobileNets and ResNet-50 model will be used for the classification. Furthermore, Jupyter Notebook Software will be used to perform the image classification and feature extraction.

ABSTRAK

Projek ini akan memberi tumpuan kepada sistem biometrik manusia. Sistem biometrik manusia boleh dibahagikan kepada dua kumpulan iaitu fisiologi dan tingkah laku. Cara berjalan akan diberikan fokus lebih dalam projek ini. Projek ini akan memfokuskan bagaimana cara untuk mengetahui identiti seseorang individu melalui cara seseorang itu berjalan. Hal ini kerana, setiap orang mempunyai cara jalan yang unik dan berbeza. *Convolution Neural Network,* (CNN) adalah kaedah yang akan digunakan dalam projek ini untuk mengkelasifikasikan setiap subjek yang diguna pakai dalam projek ini melalui pra-terlatih CNN dan untuk membandingkan antara satu sama lain untuk mengenal pasti pra-terlatih yang terbaik bagi mengesan cara berjalan seseorang individu. *Gait Energy Image* bagi dataset CASIA-B dengan berjalan secara pandangan sisi atau secara 90˚ darjah akan diguna pakai dalam projek ini. Selain itu, sebanyak 124 subjek untuk dataset CASIA-B akan terlibat dalam projek ini. Pra-terlatih bertujuan untuk mengkelasifikasikan setiap subjek tersebut. Terdapat pelbagai pra-terlatih yang sedia ada di internet. Setiap daripada mereka adalah berbeza dari segi ketepatan dan kelajuan. Model MobileNets dan ResNet-50 akan diguna pakai di dalam projek ini bagi tujuan kelasifikasi imej dan pengekstrakan ciri-ciri. Selain dari itu, perisian Jupyter Notebook akan digunakan dalam projek ini untuk tujuan mengkelasifikasikan setiap gambar.

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LIST OF ABBREVIATIONS

SB – Sensor Based

VB – Vision Based

USB - Universal Serial Bus

CASIA - Chinese Academy of Sciences Institute of Automation

OU-ISIR - Osaka University Industrial Research

OUMVLP - Multi-View Large Population Dataset

CMU - Carnegie Mellon University

UMD - University of Maryland

CCTV - Closed-circuit Television

IEEE - Institute of Electrical and Electronic Engineers

SVM - Support Vector Machine

LDA - Linear Discriminant Analysis

PCA - Principal Component Analysis

CNN - Convolutional Neural Network

GEI – Gait E

DNA - Deoxyribonucleic Acid

RGB – Red Green Blue

ReLU - Rectified Linear Unit

MATLAB - MATrix LABoratory

CHAPTER 1

INTRODUCTION

1.1 Background

Figure 1.1: Types of Biometric system [1]

Nowadays, the human biometric recognition has been widely used in many kinds of fields especially security purpose. For instance, at airport and banking where all the personal data are very important such as their private data such as bank account number. This biometric can be divided into two groups as shown in **Figure 1.1**, which is physiological and behavioral. The physiological are more to body structure and behavioral more to pattern of an individual. For instance, fingerprint, hand, retina, face, and DNA are the examples for physiological while keystroke, signature, voice and gait are the examples for behavioral [1].

What is Gait? Gait is a manner or style of walking [2]. Every person has their own unique walking style. Besides, the most prevalent mode of mobility for moving independently and efficiently is walking. The gait is a movement that consists of a whole-

body translation enabled by the repetition of body segment motions while remaining balanced [3]. On the other hand, gait recognition does not need the participants' active involvement. Traditional biometric characteristics are acquired over a short distance utilizing touch or contactless sensors. In certain cases, a facial feature might help overcome this constraint. However, when the image sensor is far enough from the person, the resolution of a facial picture rapidly decreases, reducing the accuracy of face recognition substantially [4]. In other words, gait recognition is add-on technique for recognize person at a distance by the way the person walks.

Furthermore, gait recognition algorithms are classified into two types: model-based approaches and model-free methods. Technically, the goal of the model-based method is to model human body structure in order to recognize it. Model-based method have a significant computational cost and tend to have lower performance compare Model free based method. While model free based method is based on appearance can do classification regardless of the underlying body structure. It provides better results, and the silhouette information of the human body is mostly used widely especially in this case [5]. In this project, behavioral traits such as gait for human biometric identification will be used in conjunction with previous research on gait recognition.

Gait Recognition will bring a lot of benefits to the user. For instance, this gait recognition can identify the subjects up to 500 feet away which is will make the work a lot easier. Besides, it also can be coupled with other biometrics such as face recognition which mean will double the accuracy logically. Furthermore, gait recognition is less expensive compared to face recognition and iris recognition. This is due to; the gait recognition only needs low-resolution of photos for gait pattern extraction compared to face recognition which need high quality of photos in order to detect the subject and same as the iris recognition. In addition, compare to other biometric for security purpose, it is really hard to recognize if there are any burglars enter a house because the burglars usually used masked, caps, and gloves to cover their face and fingerprints. Gait recognition is the most effective way to handle this kind of situation with high accuracy.

However, there are limitations with this gait recognition that might reduce its accuracy, such as the difficulty in detecting someone walking while carrying a suitcase. Other than that, the other issues that might decrease its efficiency is appearance changes, speed differences, people walking together, occlusion, and impact on gait signature

creation. The past researcher already addresses these issues and try to improve the gait recognition with more dataset and improve in terms of technology that been used. In this project, the main target is to investigate current state-of-the-art research and developments in gait recognition alongside to determine the individuals by using CASIA Dataset-B because it is widely used. According to Universitas Telkom et al. [6], the experimental results indicate that the proposed method achieved the excellent recognition rate of 98.8% with less training time using CASIA-B Gait dataset. In addition, the (CNN will be used) models of Conventional Neural Networks (CNN) will be used to test the accuracy of gait recognition validation.

1.2 Problem Statement

Nowadays, the demand of this biometric is increasing. As mentioned before, for security purpose it is crucial to own this kind of technology because it is does offer a lot of advantages for the country who used this kind of technology. Every personal data will not be kept in a card like nowadays, it might be cordless in the future and all the private data might store at the personal computer or phone for example. In other words, the implementation of biometric technologies nowadays is a must for every city especially at developed countries as in Malaysia as well, with CCTV are installed around the corner of every city to ensure these biometric monitoring work successfully. Besides, one of advantages of gait recognition is that gait recognition can detect a subject from at least 500 feet which is equivalent to 152.4 meter. It is considering quite a distance that this gait recognition can work. This gait recognition can improve the limitation of the others biometric recognition such as face recognition where the subject need to be closed with the face recognition system in order to recognize the subject face. Thus, it clearly stated that this gait recognition can reduce the crime cases in every country as this biometric recognition applied.

Since gait recognition is a novel biometric that has a lot of advantages due to its non-intrusive nature and the ability to be used remotely. As a result, a detailed analysis of the numerous covariate variables is necessary in order to measure the intrusiveness of gait recognition. For instance, the covariate variables might be connected to the subject, such as when a subject smiles for face recognition, or they can be related to the environment,

such as lighting, ground type, or camera arrangement. Gait is impacted by a variety of covariate characteristics such as footwear, clothes, injuries, age, walking pace, and much more as mentioned by Bouchrika et al. [8] .

Numerous researchers have studied how to identify individuals based on individual gait patterns in recent years. There are a lot of methods have been used such as Convolution Neural Network (CNN), Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and many more. Each methods have their own advantages and limitations for the feature extraction. Besides, in term of classification past researcher also mentioned classification such as Support Vector Machines (SVM) and K-Nearest Neighbors (KNN). In this project, the focus is more to Convolution Neural Network, (CNN) method as these methods will be used to recognize the gait pattern. This statement also supports that the Convolution Neural Network, (CNN) method been used widely from past researcher due to its high accuracy Wan et al. 2018 [9].

1.3 Objectives

The objective of this project is:

1. To review the existing gait recognition in term of deep learning
2. To develop the best gait recognition identification by using CNN Pre-trained Network model.
3. To validate the accuracy of the proposed method in gait recognition algorithm

1.4 Project Scope

This study or project focuses on individual recognition by the gait pattern which are identified by using Gait Energy Image-based recognition system. In this project, CASIA Dataset B will be used in this project. Lateral view or 90˚ angles view will be used from each normal walking subject to determine the accuracy on each of the selected CNN pre-trained network model such as (CNN Model) model. In this project, MobileNets and ResNet-50 model will be used in this project for the comparison. Jupyter Notebook Software will be used in order to run and develop the algorithm for image classification and extraction.

1.5 Report Outlines

Chapter 1 – Introduction

This chapter briefly explain regarding the project flow such as background of study, problem statement, objective, and project scope.

Chapter 2 – Literature Review

This chapter discuss regarding past researcher paper or journal such as their methods, technique, and accuracy of each method that been using this gait recognition. Various datasets discuss in this chapter and the method been used which is CNN also discussed in this chapter.

Chapter 3 - Methodology

This chapter will explain details regarding the whole project progress. For instance, proposed method on individual recognition based on gait pattern just like mentioned in literature review. Besides, to make it more clearer flow chart will be put on this paper to ensure it easy to understand the process and progress of the project flow.

Chapter 4 – Results

This chapter is regarding the data collection and the results from the experiment. The result will be discuss specifically based on the how things ongoing in this project.

Chapter 5 – Conclusion and Recommendations

This chapter will conclude all the findings throughout this project and will provide the recommendations based on the experience and findings for better future works.

Chapter 2

LITERATURE REVIEW

2.1 Overview

In this chapter, all the details that related to the studies of gait recognition will be discussed according to the readings and some research from the previous study, article, and journals. All the comparison and purposed dataset will be taking as consideration to decide which methods are the best for this gait recognition. As many methods were taking in consideration, as more quality the result at the end. All kinds of internet and non-internet sources were used for this project in order to collect as much as information to finish this literature review such as IEEE Xplore, Science Direct, Research Gate, Google Scholar, and any passed research or report regarding gait recognition.

2.2 Introduction to Gait Recognition

Gait by definition by English dictionary is a manner of walking or moving on foot. According to Zheng et al. [10] Humans may be identified by their distinct walking patterns, which include limb movement patterns and ground response force. Everyone has their own unique and different limb movement patterns appear to aid in the detection of persons from far away, or also known as gait recognition, while ground reaction force and its derivatives, such as footprints, are also used separately by human specialists to identify offenders. Besides, Institute of Electrical and Electronics Engineers. Madras Section et al, [11] also stated that gait recognition is the practise of recognising a person based on their walking style, this is a non-intrusive biometric that allows you to identify individuals from a distance without requiring any interaction or cooperation from the subjects. This is what makes it so appealing as a means of identification. Furthermore, gait is the only biometric that can identify a person from a long distance using low-resolution picture frames. Gait identification is based on parameters such as gait cycle,

stride length, stride breadth, and knee angles. This is due to it impacted by varied dress codes, speed variations, viewing angle variations, and light changes, it is a helpful biometric. Gait recognitions are divided into two methods of forms which are model-based and model-free approach [10]. The main different from these two methods is that the model-based tend to approach tend to recover the underlying mathematical construction of gait with a structure motion model while model-free approach gait recognition does not attempt to recover a structural human motion model with higher performance, mainly using silhouette information of the human body.

2.3 Gait Acquisition

Essentially, gait acquisition was created to acquire human gait data. Human gait data, in general, is a set of temporal-spatial data that incorporates actions of the human body through time. According to Lee and Grimson (2002), there are four methods for collecting human gait data: accelerometer, camera, continous wave radar, and floor sensor.[12] The human gait possibilities are contained within the information gathered throughout the information gathering procedure.

Singh et al., 2021 stated that [13] First-stage gait identification's primary objective is to collect gait datasets utilising a variety of sensing technologies or elements, all of which are completely different modalities. The quality of the model's output and accuracy are directly related to the quality of the data samples used to build it. Sensor-based aisle acquisition and vision-based aisle acquisition are the two primary forms of aisle acquisition.

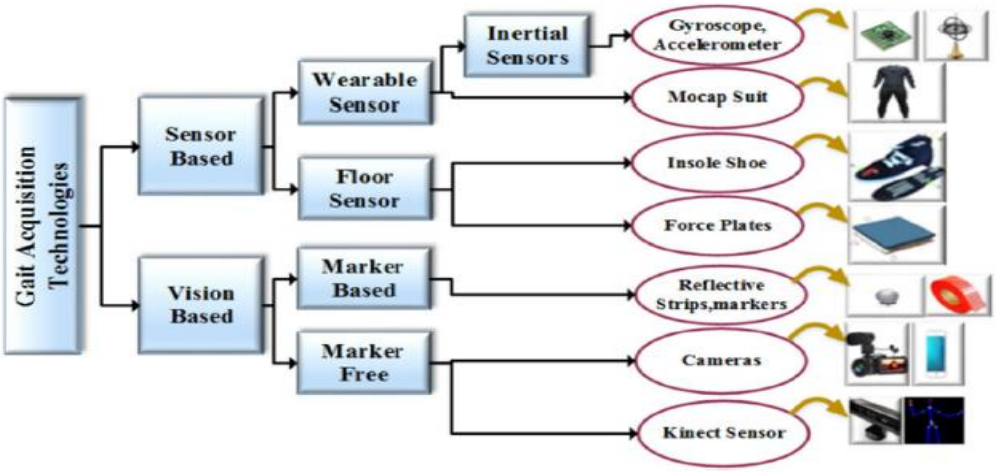

Figure 2.1: The Gait Acquisition [14]

2.3.1 Sensor Based

The two types of sensors accessible are wearable sensors and floor sensors. For quantitative gait acquisition patterns, sensor modules are coupled together to recognise certain body joints or positions on the floor. Floor sensors are sensors placed on a specific floor that generate pressure signals when someone walks across it. There were 50 sick patients and 37 healthy people who were measured using two kistler force plates throughout the course of a 10-meter corridor for their kinetics needs (ground response forces). Kistler force plates with 47 people's ground response forces were utilised to diagnose knee osteoarthritis. The RScan USB floor sensor is used in conjunction with a cumulative foot strain image database to gather ground response force characteristics with two covariates: walking speed and shoe type.

Wearable sensors are devices that are connected to certain parts of the human brain to collect sensitive data like speed, position, acceleration, and other factors used in gait studies. An inertial sensor was employed to construct temporal spatio characteristics of knee osteoarthritis patients. As a consequence, a wearable instrument has been created to identify gait sign freezing in Parkinson's patients. Acceleration in the patient's walk is measured using an on-body acceleration sensor. The characteristics of the knee joints are to be assessed for clinical examination using a recommended clothing-based sensor system that links within the fabric. A mobile-based gait recognition system, in contrast to nil-effort and live negligible-effort gait harmful assaults in real life, offers. This study

created an Android app that used an accelerometer sensor on a smartphone to collect data on gait speed. More complex equipment is required for data sensing for SB gait capture even though precise quantitative empirical evidence is supplied. Clinical therapies for Parkinson's disease, knee osteoarthritis, and other gait-related disorders frequently use these learning strategies.

2.3.2 Vision Based

The recording of visual camera gait data as well as a review of the gait cycle are part of this sensing approach. In this category, there are two sorts of markers: marker-based and marker-free. Marker-based reflective adhesive tape or markers were applied to a human body to record complex features including kinematical parameters, joint angle motion, distance, and others for future analysis. The goal of the study is to build a gait dataset with LED markers that may be utilised in therapeutic recovery treatment. The data included 212 subjects, kinematics, and Kinect restrictions, all of which were combined to create a 2D optical activity analyser. A plug-in system of walking markers with eight ocular cameras is used to acquire diagnostic data for knee sufferers. This sort of sensor has the potential to be beneficial in medical research. In today's world, Kinect sensors (depth cameras) should be utilised to determine the location of the gait joints instead of any of the sensors mentioned above. A gait detection dataset based on 3D skeletons is built using a Kinect sensor. The sensor detects red, green, and blue light aspects, as well as body and face characteristics.