REAL TIME FINGER-VEIN RECOGNITION FOR AUTOMATIC DOOR ACCESS CONTROL

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BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Real-time Finger-vein Recognition For Automatic Door Access Control

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Dedicated to my beloved parents, supervisor, seniors and friends.

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ABSTRAK

Tujuan projek ini adalah untuk membina sebuah kawalan akses pintu dengan menggunakan urat jari untuk mengenal pasti dengan masa sebenar. Peranti ini menggunakan urat jari seseorang pengguna untuk memberi akses pintu kepada pengguna yang berhak. Sebuah matrik NIR LED akan dipancarkan kepada jari pengguna di dalam sebuah kotak dan sebuah kamera CMOS NOIR Raspberry Pi akan menangkap imej urat jari dari arah bertentangan. Urat jari akan kelihatan lebih gelap dan jari akan kelihatan lebih putih daripada imej yang ditangkap. Imej tersebut akan melalui beberapa langkah pemprosesan imej untuk menjadikan imej tersebut lebih jelas dan detel urat jari akan diambil untuk dibandingkan dengan template di pangkalan data dengan menggunakan cara *Modified Hausdorff Distance (MHD)*. Jika pengguna itu berhak, pintu akan dibuka dan sebaliknya. Produk ini menggunakan sebuah Raspberry Pi 3 sebagai *microncontroller* untuk memproses imej, mengawal kamera, kecerahan NIR LED dan mengawal motor untuk pintu. *Equal Error Rate (EER)* untuk produk ini adalah serendah 7.78% yang menghasilkan ketepatan sebanyak 92.12%.

ABSTRACT

This project is to build a real-time finger-vein identification device for door access control. It is a device to capture the finger-vein image of a person to give access to the authorized user. A matrix of near-infrared light emitting diode (NIR LED) will be emitted on to the finger in a box whereby a CMOS NOIR Raspberry Pi camera on the other side of the finger will be ready to capture the finger-vein image. The veins would appear darker in the image whereas the background or the finger will be lighter. The image will then go through a series of image processing steps to enhance the image and lastly taken it's minutiae points to compare with the template in the database using Modified Hausdorff Distance (MHD). If the user is authorized, door will open and vice versa. The device is made by using a Raspberry Pi 3 as the microcontroller to process the image, controlling the camera, NIR LED's lighting and to control the motor of the door. The Equal Error Rate (EER) of the device is 7.88% which yields an accuracy of 92.12%.

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LIST OF ABBREVIATIONS

CCD	-	Charge Couple Device
CLAHE	-	Contrast Limited Adaptive Histogram Equalization
CMOS	-	Complementary Metal Oxide Semiconductor
CNN	-	Convolution Neural Network
DNN	-	Deep Neural Network
ERR	-	Equal Error Rate
FAR	-	False Acceptance Rate
FRR	-	False Rejection Rate
KNN	-	K-Nearest Neighbor
LED	-	Light Emitting Diode
MHD	-	Modified Hausdorff Distance
NIR	-	Near Infrared
PCA	-	Principal Component Analysis
RANSAC	-	Random Sample Consensus
SVM	-	Support Vector Machine

CHAPTER I

INTRODUCTION

1.1 Project Introduction

This project is to make a real-time finger-vein recognition for automatic door access control system. It is a project where by using a person's finger-vein to give access through a door. In other words finger-vein is used as a personal password. This project focuses more towards the real-time finger-vein recognition part as that area in this project is more complex than the automatic door section.

In recent years, there are many ways used as a key for a door lock. The most conventional way is to use the traditional lock and key to open a door. However, a more modern way would be to key in a passphrase or a set of numbers called as password to replace the key. But, both methods possess something in common, which is not fool proof of human carelessness. A key can be misplaced somewhere else, the same goes for the password which can be forgotten by the person thus losing the ability to unlocking the door. Besides, both the traditional key and password method does not have the ability to distinguish if the right person with the right authorization is allowed to be given access into the premises. For example, a stolen key will give access to the thief into the premises. The same goes for the password where the person who knows the password will be able to enter the premises. This shows that there is no unique trait in the key or password other than just having the sole purpose of unlocking the door. Thus, the conventional way of using key and password is deemed unreliable to a certain extent.

Biometrics, in which the measurements are related to human characteristics can be used to replace the conventional key or password. Biometrics uses parts of the body which are found to be distinctive from one person to another. Example of biometrics identifiers such as fingerprint, vein, iris, face, voice and many more. By using a biometric trait as the password, human carelessness will no longer pose a problem because a biometric password uses the part of the body as the password, there is no way to carelessly forget or even easily forge a person's biometric trait. Besides that, it is very unique as it differs from one person to another, which makes it a unique password that belongs to only a person. Thus, the biometric password could distinguish a person as it is personally unique.

Finger-vein biometric is a new biometric method which utilizes the vein patterns inside one's fingers for personal identity identification. Vein patterns are different for each finger and for each person; and as they are hidden underneath the skin's surface, forgery is extremely difficult [1]. Besides that using finger-vein biometric as the authentication is better in several aspects compared to other biometric traits. Table 1.1 shows the comparison of major biometrics method.

From Table 1.1, it can be seen that by using vein biometric, the cost is moderate at the same time it has very great accuracy and anti-forgery characteristics. Table 1.1 supports that veins are better suited compared to other biometrics method.

Table 1.1: Comparison of major biometrics method [1]

Type Of Biometrics	**Security**		**Convenience**		
	Anti-Forgery	**Accuracy**	**Speed**	**Cost**	**Size**
Fingerprint	Bad	Average	Average	Good	Good
Iris	Average	Good	Average	Bad	Bad
Face	Average	Bad	Average	Bad	Bad
Voice	Average	Bad	Average	Average	Average
Vein Pattern	Good	Good	Good	Average	Average

1.2 Objectives

The main agenda in this project is to design and develop a system which functions in real-time that can capture finger-vein images followed by processing the image for recognition to allow or restrict access through an automatically controlled door. The sub-objectives regarding the main agenda are as follow:

- To create a finger-vein identification system using Raspberry Pi to overcome the insufficient memory capacity problem
- To solve the uneven illumination problem when capturing finger-vein images
- To create a low-cost finger-vein identification system

1.3 Problem Statement

To design and develop a unified system which can work in real-time, capture images, and 'process' images would surely require a lot of memory to execute. To work in real-time, the entire system's process must be executed at a very short time. Besides that, by capturing images, it requires memory to keep those images into the database to be kept as a comparison in the future for authentication. Thus, a huge memory is required to keep the images. Besides, processing the images pixel by pixel would use up a lot of processing speed alongside with the system's memory. Therefore, it is a problem for a low-memory capacity microcontroller to be used which disallow images to be kept and process in the microcontroller.

Apart from the insufficient memory problem, there is also a problem in capturing finger-vein images. The problem is caused by the skin thickness as well as the body temperature which varies from one person to another. The problem occurs, during the image capturing process, where the NIR (Near Infrared) light would be used to penetrate the finger and then the infrared camera would be used to capture the image. When that happens, there are times where at a constant NIR light intensity, with two different fingers going through the same image capturing process would yield an entirely different result which one might have a clearer picture of the finger-vein and another might not even see the finger-vein. Thus, the illumination problem caused by the insufficient or over sufficient intensity of the NIR light is a major problem to be solved as the quality of the image would affect the authentication part later in the system.

1.4 Scope Of Work

In this project, the scope of work will be divided into mainly three parts. The parts are hardware, software and performance measures.

The hardware is the physical aspects of the system such as the camera, NIR light illuminating circuit, door locking circuit. The scope of the hardware would be to use the Raspberry Pi 3 as the microcontroller together with the pi camera which had its IR filter removed alongside with a matrix of NIR LED's to be used as the light source to shine on to the finger.

The software is the internal aspect of the system where in this project, Python would be used as the platform to code the processes in the system. Python is used to do all image processing techniques including the performance measures as well. The main library used for the image processing in Python is OpenCV.

The third scope which is the performance measure is used to check the quality of the hardware and software. The performance would include the quality inspection of the image and also some common biometric measurements. The common biometric measurement which are usually used are False Rate Rejection (FRR), False Acceptance Rate (FAR) and Equal Error Rate (ERR).

CHAPTER II

LITERATURE REVIEW

2.1 Finger-Vein Biometric System

A Biometric recognition system comprises of two types of stages which are enrollment and authentication. The enrollment and authentication process is as shown in Figure 2.1. In enrollment stage, the finger-vein in this case would have its feature extracted and keep in the database for future authentication use. For authentication process, it can be used in either verification or identification. The finger-vein feature extracted will then be used to compare with the available information in the database that had been done in the enrollment stage.

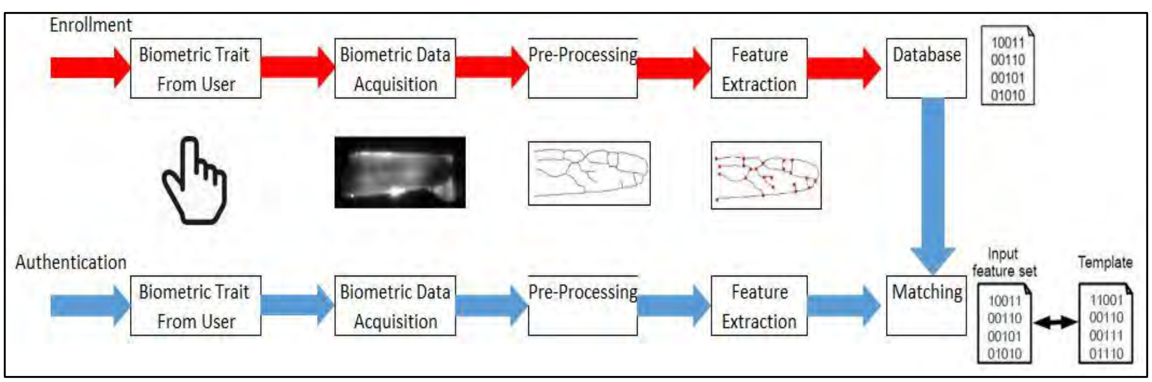

Figure 2.1: Enrollment and Authentication process in finger-vein biometric recognition system

2.1.1 Type Of System

2.1.1.1 Identification System

Identification systems are described as a 1-to-n matching system, where 'n' is the total number of features in the database, because the system would match the extracted feature to the whole database in the system. This system is use to identify who is that person with the particular features presented.

By referring to Figure 2.2, the user would directly present their biometric trait into the system, then the system would cross check the biometric trait with every template in the database. Identification system may require more time as it cross checks with every template in the database but it requires less hardware in comparison with verification system as it does not need to have any identification process. Furthermore, identification system is only applicable to only a system which have small number of database due to time constraints.

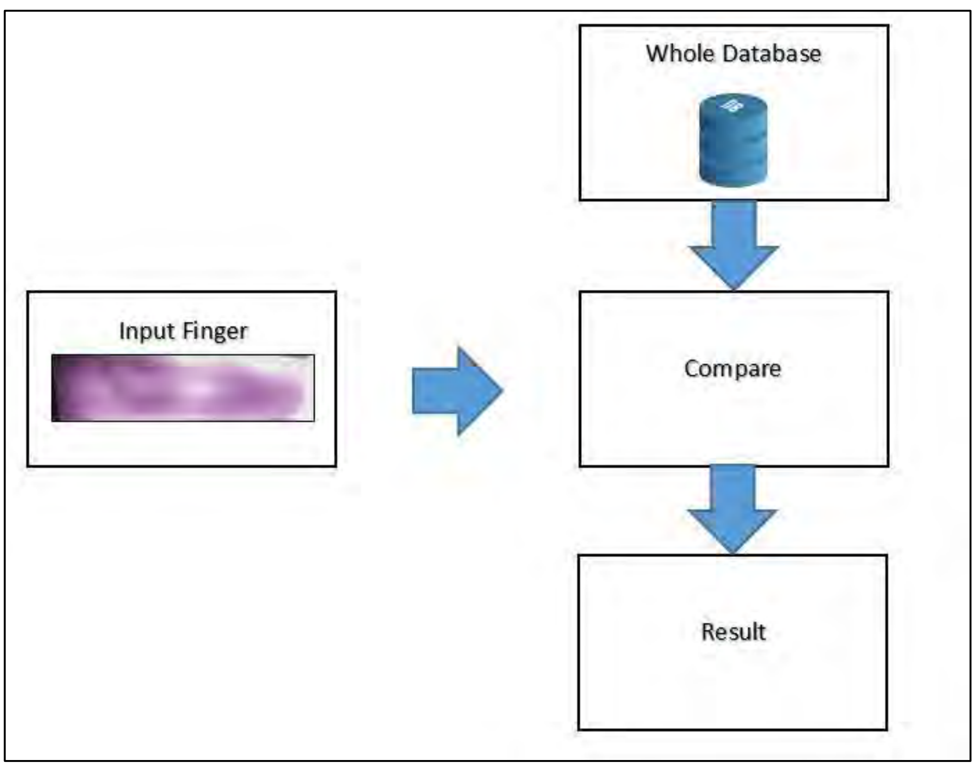

Figure 2.2: Identification System

2.1.1.2 Verification System

Verification systems are described as a 1-to-1 matching system because the system would match the extracted feature to only a certain database in the system. Since verification is to check whether the features presented is the right person or not. For example, an individual presents himself or herself as a specific person, the system will then only compare the finger-vein features to that specific person's database. This will reduce the amount of time in comparing the features as the amount of template features compared is lesser.

By referring to Figure 2.3, before inserting the biometric features, the user would need to insert a tool to prove the user, it could be a username and password, could be RFID could be anything before inserting the biometric trait. The biometric trait will then be compared with only that particular person's template instead of the whole database. Verification system is faster compared to verification system but requires more hardware.

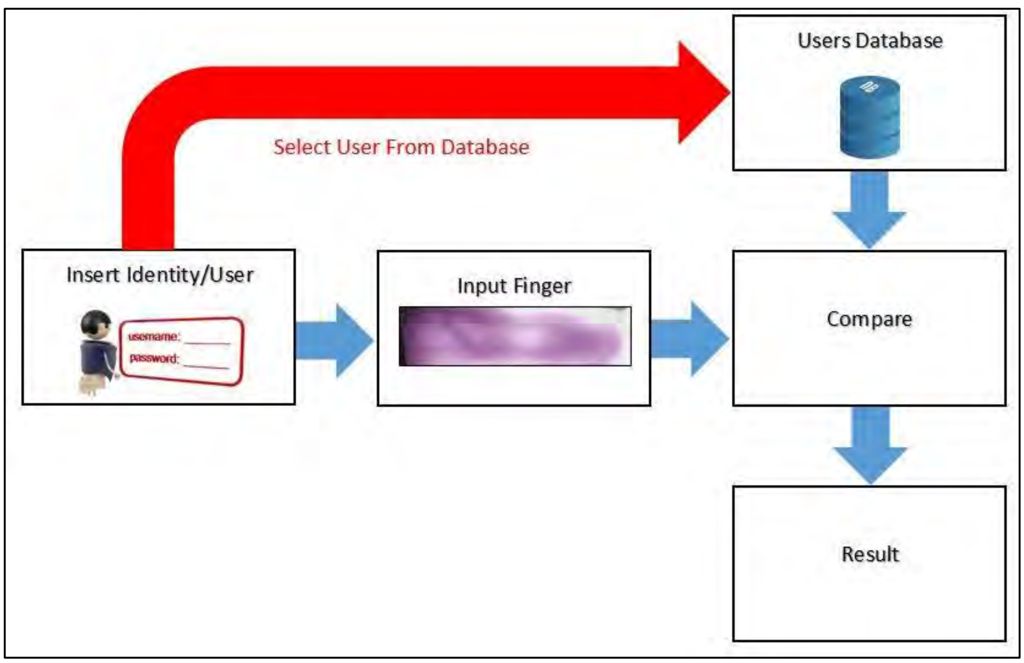

Figure 2.3: Verification System

2.2 Type Of Camera

There are two types of camera to be chosen which is CMOS (Complementary Metal Oxide Silicon) and CCD (Charged Coupled Device). Most camera's in the market uses CMOS camera especially in webcams as the use of CCD camera in webcam had stopped since the year 2012. CCD camera still can be found in expensive cameras where mostly used in astronomy.

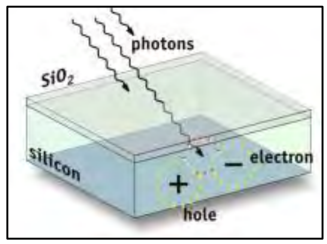

Figure 2.4: Image sensors converted to electrical signal

Both type of image sensors CMOS and CCD both uses the same concept to convert light which is by using the photoelectric effect to create electrical signal from light.

2.2.1 CMOS Camera

CMOS image sensors uses transistor at each pixel to move the charge through traditional wires. Typically a CMOS image sensors includes amplifiers, noise-correction, and digitization circuits, enabling the sensor to output digital data directly at each pixel.

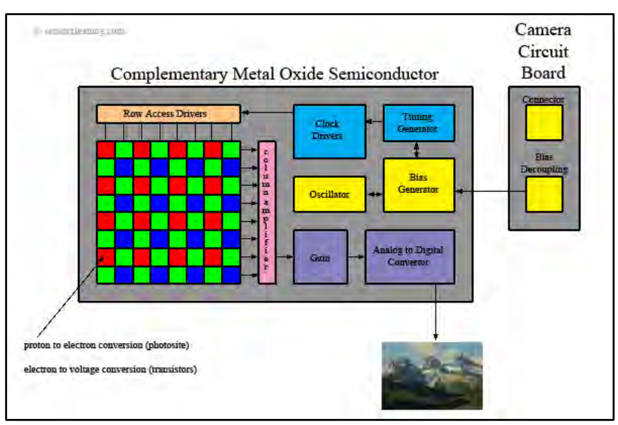

Figure 2.5: CMOS image sensor's charge move in the sensor

2.2.2 CCD Camera

In the CCD image sensor, the CCD use a special manufacturing process to transport charge across the chip without distortion. The CCD image sensor also, every pixel's charge is transferred to a very limited output unlike the CMOS where every pixel has its own output. The CCD image sensor is proven to produce a better image than the CMOS image sensor but at a higher cost.

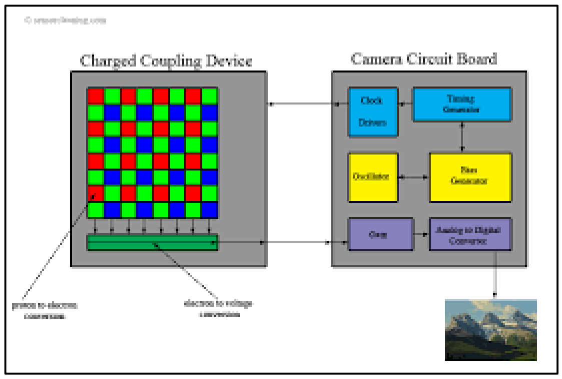

Figure 2.6: CCD image sensor's charge move across the sensor

2.3 Capturing Finger-Vein Method

There are two types or ways to capture the finger-vein method. The first method is called as the 'Light Reflection Method', and the second method is called as 'Light Transmission Method'. The light reflection method uses the reflection of the NIR light shine to the finger at an angle and the camera is situated exactly below the finger to capture the image. The light transmission method is the method where the light is placed at another side of the finger while the camera is placed at another side of the finger (finger is placed in between the light and the camera).Figure 2.7 shows both type of finger-vein capturing method.