FINGERPRINT BASED STUDENTS' ATTENDANCE SYSTEM

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CERTIFICATION

This project with the title

FINGERPRINT BASED STUDENTS' ATTENDANCE SYSTEM

Submitted by

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(CPE/13/1076)

Has satisfied the regulations governing the award of degree of

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DECLARATION

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DEDICATION

I dedicate this research work to God Almighty, who has been my all in all. I also dedicate this work to my parent Mr. and Mrs. Bashiru Bolaji, for their support financially and morally towards my education.

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ABSTRACT

Attendance is typically a list of people present at a particular event. Manual approach of attendance taking has not been very effective due to difficulty in keeping the attendance list over a long period of time, unnecessary time wastage during writing or signing, improper documentation, students forgetting to write or sign the attendance paper among others. The aim of this project is to develop a technology assisted attendance system that will enhance efficient and effective means of taking attendance using fingerprint.

Fingerprint was used as the unique physiological trait of an individual. This attendance system involved data acquisition of fingerprint samples of 44 students of the Federal University Oye – Ekiti. Image preprocessing techniques which includes image gray scale conversion, binarization, central line thinning of binarized image, dilation of thinned image and thinning of dilated image were carried out on the acquired data. The features of the preprocessed data were extracted using minutiae matching and classification of the extracted features was done using Euclidean distance. Evaluation was done using False Acceptance Rate (FAR), False Rejection Rate (FRR) and Accuracy.

The attendance system was developed using MATLAB R2015a. Experiment was conducted with 168 sample images (both left and right thumb fingerprint) selected to train the system and 96 sample images (both left and right thumb fingerprint) to test the system's functionality. The system has a False Accept Rate of 0.83, False Reject Rate of 0.01. It has an accuracy of 87% with average execution time of 4.81 secs.

This project has developed a software prototype of a fingerprint based attendance system. The system can be improved by implementing it as a hardware prototype that uses real – time fingerprints from individuals during recognition as opposed to the currently implemented software prototype which uses offline images acquired earlier.

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LIST OF ACRONYMS

Acronyms	Meaning
AI	Artificial Intelligence
ANN	Artificial Neural Network
CN	Cross Number
CPN	Counter Propagation Network
CPU	Central Processing Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
ESIC	Embedded Smart ID Card
FAR	False Acceptance Rate
FPCA	Fast Principal Component Analysis
FRR	False Rejection Rate
ICA	Independent Component Analysis
KNN	K – Nearest Neighbor
LDA	Linear Discriminant Analysis
LMS	Learning Management System
LSA	Latent Semantic Analysis
MGF	Modified Gabor Filter
OFDA	Optimized Fisher Discriminant Analysis
PCA	Principal Component Analysis
PET	polyethylene teraphthalate
PVC	polyvinyl chloride
RFID	Radio Frequency Identification
SOFM	Self Organization Feature Map
SOM	Self Organization Map
SVD	Singular Value Decomposition
SVM	Support Vector Machine

CHAPTER ONE

INTRODUCTION

1.1 Preamble

Attendance is typically a list of people present at a particular event. Attendance taking is carried out at organizations in order to determine the total number of employees present or absent from work. In an institutional organization, apart from monitoring staffs' commitment to duty, attendance taking plays a major role in justifying the academic outcome of students by stating the number of time students attend lectures and also stating if they are eligible to write the examination or not. A student is said to be eligible if he/she meets up with the standard of the institution (i.e. at least 75% attendance) for the semester.

Attendance could be taken manually (paper based) using attendance sheets/registers. This method of attendance taking is being considered obsolete due to the advancement in attendance system. Attendance taken could also be automated (technology assisted) using electronic equipment or computers to identify an individual through electronic tags, smartcard, bar-code, magnetic stripes cards, biometrics (Olanipekun & Boyinbode, 2015).

Biometrics is defined as the distinctive measurable characters and traits of human body used to label and describe individuals (Adeyanju, Omidiora, & Oyedokun, 2015). It is the most widely used area which assist in identifying an individual through his physiological properties (Chaurasia, 2012). Any trait of human body differentiating him from the another person will be used as unique biometric data of such person for his identification (Falohun, Fenwa, & Oke, 2016). The biometric traits include: face, speech, palm vein, finger vein, iris and fingerprint.

1.2 Statement of the Problem

In most institutions in the developing countries, students' attendance taking is carried out manually using paper sheets. This approach has not been as effective due to difficulty in keeping the attendance list over a long period of time, unnecessary time wastage during writing or signing, improper documentation, students forgetting to write or sign the attendance paper, lecturers forgetting the attendance list in the classroom, student writing or signing illegally for an absentee (Olanipekun & Boyinbode, 2015). Automated method of attendance taking serves as a solution to the above challenges encountered by the manual method.

Automated attendance system is used to track student's availability as well as enhance class security. This method involves the use of electronic tags (Ling, 2012), smartcard (Wambugu, 2011), bar-code (Sudha, Shinde, Thomas, & Abdugani, 2015), magnetic stripes cards (Deugo, 2015), Radio Frequency Identification (RFID) (Nainan, Parekh, & Shah, 2013),biometrics features such as iris, voice and fingerprint recognition among others (Shoewu, Makanjuola, & Olatinwo, 2014).

Electronic card-based attendance provides a faster and convenient means of taking attendance. This system uses a computer based single chip on subsystem, interfaced serially to the serial port of the digital computer (Shoewu, Olaniyi, & Lawson, 2011). One of the disadvantages of this system is that not all computer systems possess serial port and the smart card can be easily misplaced by student which will prevent him or her from taking attendance. Radio Frequency Identification (RFID) is another means of solving problems encountered by taking attendance manually. The system is based on students' card to grant or deny students from taking attendance. The flaw of the system is that it can lead to impersonation (Saheed, Hambali, Adeniji, & Kadri, 2017). The introduction of biometrics system can play a role in solving these challenges.

Biometrics attendance system makes use of biometric traits of students such as iris, voice and finger print recognition among others to verify and identify such students. This system solves the problem of lost or stolen cards as it requires the physical presence of students. Fingerprint recognition is the readily available feature of biometrics, which provides an unbeatable, dependable and faultless identification of human beings. It is the most matured and accepted biometric system. When compared to other traits, it has been proved that fingerprint is the most accurate (Chaurasia, 2012).

1.3 Aim and Objectives

The aim of this project is to develop a student attendance system that is based on authentication using fingerprint recognition. The specific objectives are

1. To design a fingerprint based students' attendance system using Minutiae Matching Algorithm for feature extraction

2. To implement the designed system.
3. To evaluate the performance of the system.

1.4 Scope of the Study

This project will develop a prototype of fingerprint based students' attendance system. The system will be used to advance attendance taking process at various institutional organizations, although it could also be used in other organizational sector such as bank and many others. This attendance taking process will be limited to the students of the institutions; however, it could also be used to take staffs attendance. This project will focus on fingerprint only among other biometric traits such face, iris, voice recognition etc. basically for attendance taking. However, it could also be useful in other areas such as security/access control among others.

Minutiae Matching Algorithm will be used for feature extraction. Other feature extraction algorithm includes Linear Discriminant Analysis (LDA), Latent Semantic Analysis (LSA), Independent Component Analysis (ICA), Fast Principal Component (FPC) Analysis.

Euclidean distance will be used for image classification and recognition in this project. Many other classifiers that could be used are Self Organization Map (SOM), K – Nearest Neighbor.

1.5 Methods of the Study

The methods to be used in achieving this project will include the following:

1. Continual review of relevant literatures related to attendance, biometrics, image processing and feature extraction.
2. Interaction with attendance system experts and biometric system experts.
3. Design of fingerprint biometric based attendance system.
4. Biometric data of at least forty users will be collected.
5. Appropriate preprocessing will be carried out.
6. Feature extraction would be done on the preprocessed biometric images using Minutiae Matching.
7. Classification with Euclidean distance.

8. Evaluation of the implemented biometric system using False Acceptance Rate (FAR) and False Rejection Rate (FRR).

1.6 Significance of the Study

1. **Financial Infrastructure Security**: Biometric system can be applied for various applications for security, restricting unauthorized access to places where security needs to be enhanced. Infrastructure security of places like banks, ATM station etc. can be improved using biometric system (Esan, Ngwira, & Osunmakinde, 2013).

2. **Access Control**: Biometric system is very vital in limiting access to a secured area such as airports, borders, immigration offices, houses etc. whereby only those with their biometric details in the system are granted access to the area (Adewale, 2016).

3. **Registration Process**: Different bodies that requires registration before admitting an individual into their organization has imbibed the use of biometric system into their registration process as it aids easy assigning of details/properties to such individual and it can easily be refrained from him/her if the need arises.

4. **Forensic**: Biometric can help in terrorist, fugitives, missing children identification. Biometrics can be used in identification (1: N matching) and verification (1:1 matching) (Mishra & Trivedi, 2011).

CHAPTER TWO

LITERATURE REVIEW

2.1 Attendance

Attendance is typically a list of people present at an event. Attendance could be taken manually (paper based) using attendance sheets/registers. It could also be automated (technology assisted) using electronic equipment or computers. Attendance taking is carried out at business organization in order to determine to the total number of employees present or absent from work (Udinn, 2014).

The paper based attendance has been the commonly used type of attendance system in various organizations. This method requires manually writing of names or signing on sheets of paper. This system is becoming archaic with time due to the challenges that comes with it; difficulty in keeping the attendance list over a long period of time, unnecessary time wastage during writing or signing, improper documentation, students forgetting to write or sign the attendance paper, lecturers forgetting the attendance list in the classroom, student writing or signing illegally for an absentee among others (Sudha, Shinde, Thomas, & Abdugani, 2015). Also, the fact that there is better way of taking attendance with less stress and more efficiently.

2.2 Technology Assisted Attendance System

This system makes attendance taking easier and more accurate. It provides a robust, secure and automatic attendance system with a more organized record keeping compared to the paper based attendance system. It reduces risk of errors that are common in paper based attendance system. Tracking of attendance records can be carried out easily with this method of attendance system because every person has a unique identification that differentiates him/her from others (Deugo, 2015). This system includes the use of barcode, smart cards, RFID, biometrics systems among others.

2.2.1 Barcode

Barcode Student Attendance System is a type of technology assisted attendance system that uses software which utilizes barcode scanner. This scanner integrated on the computer system to record and maintain the attendance of the students. The main hardware used in this system is the barcode scanner whose function is to read the barcode that will be at the back of students ID card consisting of each students details (Sudha, Shinde, Thomas, & Abdugani, 2015). A barcode is a machine readable representation of information in a visual format. Barcode is of different types such as;

i. Linear barcodes which is made up of lines and space of various widths that create specific pattern. And

ii. Matrix barcodes, also known as 2D barcode. Although, it is similar to linear barcodes, it represents more data in per unit area

There are different types of barcode scanners which include;

i. **Pen – type reader**: It consist of a light source and photodiode placed next to each other in the tip of a pen.

ii. **CCD reader**: uses an array of hundreds of tiny light sensors lined up in a row in the head of the reader.

iii. **Smart phone camera**: Has the ability to read both QR codes as well as scanning a barcode in order to bring out information such as price comparisons and user review.

iv. **Handheld scanner**: This is scanner, which has a handle and a trigger button to switch on the light source. And

v. **Automatic reader**: Reads barcoded documents at high speed (Sudha, Shinde, Thomas, & Abdugani, 2015).

Shown in Figure 2.1 is the processes of a barcode attendance system

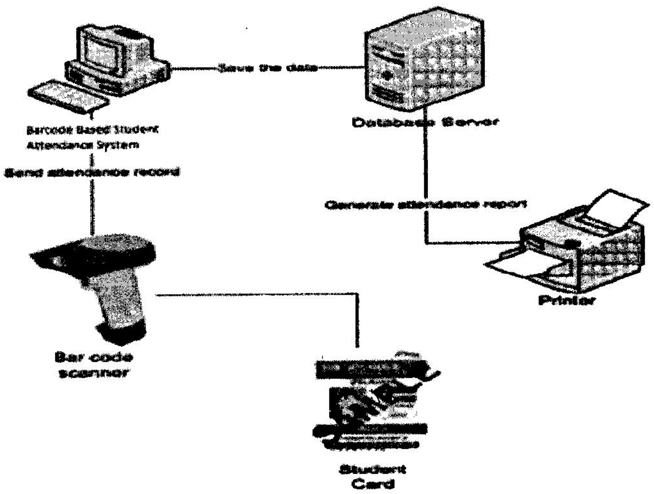


Figure 2.1 Barcode attendance system (Sudha, Shinde, Thomas, & Abdugani, 2015)

2.2.2 Smart Cards

Smart card is an electronic device with integrated microprocessor and computation manipulation incorporated into a plastic card used to store data. This smart card can as well be interfaced through Wi – Fi/Bluetooth to Android phone/laptop through android app or through windows app (Kumar & Manimohzi, 2015). The smart card consists of a SIM card sized microprocessor mounted on a larger plastic card as shown in Figure 2.2. It is supplied with energy and a clock pulse from the reader through the contact surface. The small physical size of the smart card houses the card in a larger card providing physical protection and easing the use and handling of the card. The larger card is governed by the ISO 7810 standard while the positioning of the contacts on the card is governed by the ISO 7816 – 2. The standard defines three formats of the larger card as ID-1, ID-00 and ID-000 format.

These cards are usually programmed with the data required for when the smart card is used later on. A CPU is embedded in the smart card chip. This CPU is fully flagged system with its own operating system, which enables the running of other programs on the smart card. Smart cards could be contact or contact-less smart card depending on the external circuitry (Wambugu, 2011). The external circuitry and embedded chip of the smart card enables it to communicate between the chip and other electronic devices.

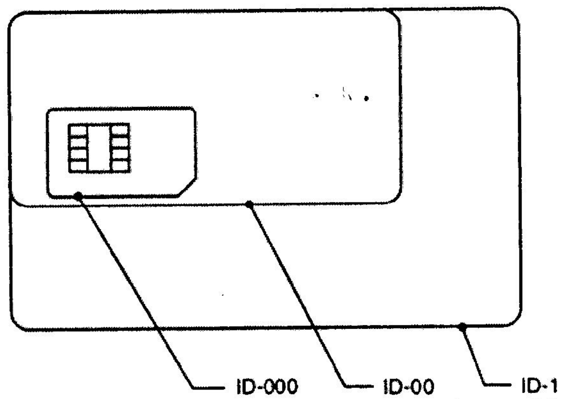


Figure 2.2 Architecture of a smart card (Wambugu, 2011)

2.2.3 Radio Frequency Identification (RFID) System

Radio Frequency Identification (RFID) is a technology that is commonly used to transmit and receive information without wires. This technology transmit data through radio waves from an RFID tag attached to an individual by the reader for automatic identification. This system consists of two main components; the reader and the tags. The tag is a kind of memory device that transmit the data stored in it when scanned. It is attached to a student that is to be identified with the details of such student stored in a microchip. The reader detects tags that are within its frequency range by sending a pulse of radio waves to the tag and listens for its response. The response received from the tag consist of the details of the students whose tag is read (Moharil & Dandare, 2016).

RFID based attendance system is divided into two main parts; the hardware part which include RFID reader, tags and host computer. The software part which is the host system application. This technology is implemented such that lecturer or administrator can log into the system and check necessary information in the application, which keeps a log of the ID, time and date of every student that enters the lecture room for lecture. It can also register new student using the tag ID of each tag (Hussain, Dugar, Deka, & Abdul, 2014). The RFID is made up of a graphical user interface that consist of the database system used to store all the student details, date and time. This page consists of the view for displaying student information and other options of action to be performed. Admin (consist of several buttons with their associated functions which can only be operated by the admin), database (consist of course record button, student record button and student attendance record button, displaying the pages of the names associated to the buttons), student evaluation (it entails the eligibility and non-eligibility button which displays the names of students that are or are not qualified to sit for the examination of the stated course), admin registration (gives room for registering administrator's account by providing username and password, an then storing them in the database), student record and course record (as their names implies, it details the names of registered students and courses for a particular semester). Figure 2.3 and 2.4 shows different types of RFID tags and an automated attendance system respectively.

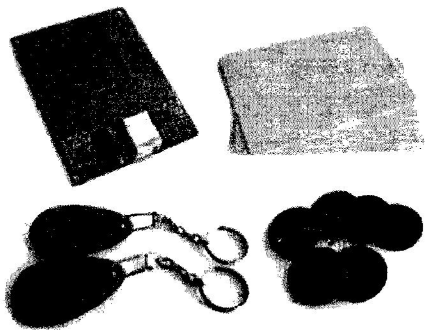


Figure 2.3 Types of RFID tags (Nainan, Parekh, & Shah, 2013)

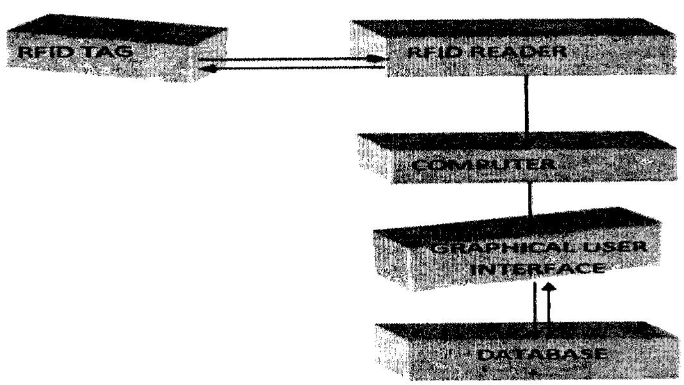


Figure 2.4 Automated attendance System (Olanipekun & Boyinbode, 2015)

2.3 Biometrics

Biometrics is defined as the unique (personal) characteristics or traits of human body which are used to identify each human. Any detail of the human body which distinguish an individual from another will be used as unique biometric data to serve as that person's unique identification (ID). Biometric systems collect and stores this data in order to use it for identifying or verifying personal identity (Falohun, Fenwa, & Oke, 2016).

Biometrics system can be in two forms: verification ("one – to – one" matching) which is used to verify whether a person is who he or she claims to be and identification ("one – to

– many" matching) whereby a person's presented biometric is compared with available biometrics templates in a database in order to get a match (Saheed, Hambali, Adeniji, & Kadri, 2017).

Biometric system work by first capturing sample of human trait, such as taking a digital coloured image for finger recognition, or digital sound signal for voice recognition. The sample is then transformed into a biometric template using certain mathematical function. This template provide an efficient and highly discriminating representation of the feature, which can then be compared with other templates in order to determine identity (Libor, 2003). Biometrics systems have been developed base on human traits which include speech, iris, palm vein, face, fingerprint among others. Table 2.1 shows the various available biometric traits of human.

Table 2.1 Various Biometric Traits of Human (Jain, Ross, & Prabhakar, 2004)

Biometric identifier	Universality	Distinctiveness	Permanence	Collectability	Performance	Acceptability	Circumvention
DNA	H	H	H	L	H	L	L
Ear	M	M	H	M	M	H	M
Face	H	L	M	H	L	H	H
Facial thermogram	H	H	L	H	M	H	L
Fingerprint	M	H	H	M	H	M	M
Gait	M	L	L	H	L	H	M
Hand geometry	M	M	M	H	M	M	M
Hand vein	M	M	M	M	M	M	L
Iris	H	H	H	M	H	L	L
Keystroke	L	L	L	M	L	M	M
Odour	H	H	H	L	L	M	L
Palm-print	M	H	H	M	H	M	M
Retina	H	H	M	L	H	L	L
Signature	L	L	L	H	L	H	H
Voice	M	L	L	M	L	H	H

KEYS

H – High

M – Medium

L – Low

2.3.1 Speech Recognition

Speech is the most natural means of human communication. Speech recognition is the use of computer to detect, recognize understand and transcribe what was spoken by human. Over the past five decades, research in automatic speech recognition by machine has attracted a great deal of attention due to the desire to automate simple task requiring human – machine interaction and curiosity about the mechanisms for mechanical realization of human speech capabilities. Speech technologies are now commercially available for interesting range of tasks such as; machines responding correctly and reliably to human voices and providing useful and valuables services (Juang & Rabiner, 2004). Figure 2.5 shows a speech recognition system, which shows a stream of sampled and digitized speech data, speech recognizer and the output speech. Speech recognition is faced with some challenges such as linguistic patterns being hard to characterized, inexact pattern matching algorithms and systematic or natural variations in acoustic patterns (Adewale, 2016).

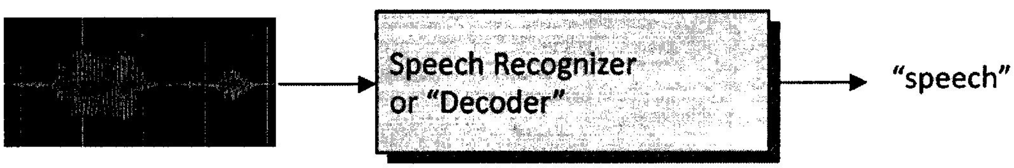


Figure 2.5 A speech recognition system (Raj & Singh, 2011)

2.3.2 Iris Recognition

Iris is an external visible, protected organ whose epigenetic pattern and texture remains stable throughout adult life. It is the pigmented elastic tissue that has an adjustable circular opening in the center which lies between the cornea and the lens of human eye. It is made of different layers; epithelium layer (contains dense pigmentation cells), stromal layer (lies above the epithelium layer, contains two iris muscles, blood vessels and pigment cells). The colour of the iris is determined by the density of stromal pigmentation (Libor, 2003).

Iris recognition gives accurate result and it is highly scalable, as the iris pattern remains the same in a person's lifetime. This characteristic has made iris very reliable and attractive for use as a biometric for recognition of individuals. The process of iris recognition involves taking the picture of iris with a capable camera, storing it, and comparing it with the individuals eyes using mathematical algorithms (Anadi, 2015). The Figure 2.6 shows iris recognition procedures.

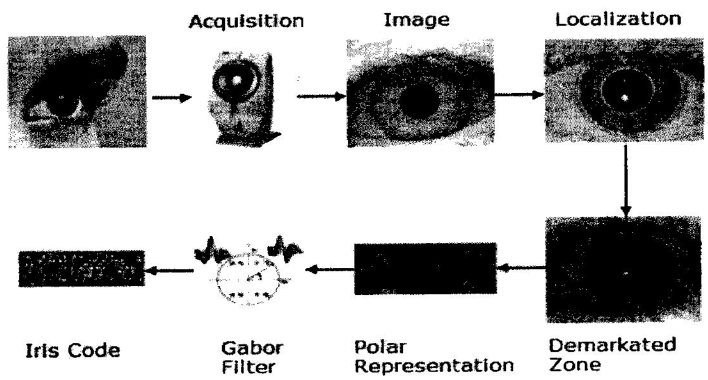
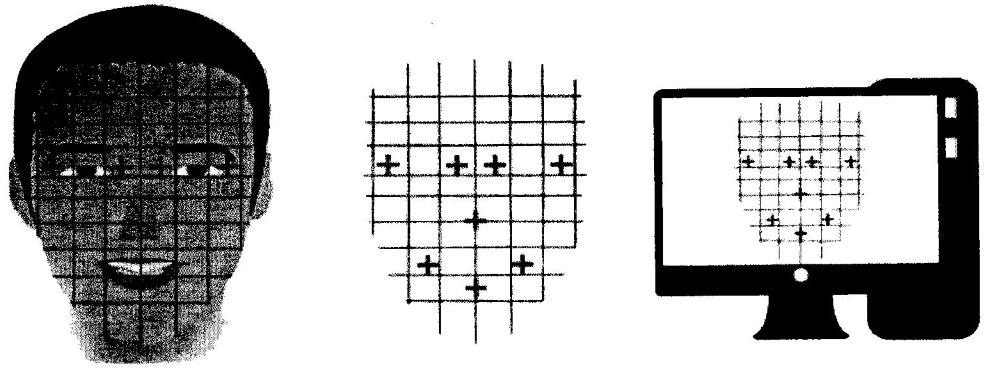


Figure 2.6 Iris recognition system (Anadi, 2015)

2.3.3 Face Recognition

Face is the location and shape of facial attributes such as eyes, eyebrows, nose, lips among others. Face is one of the most common parts used by people to recognize each other. The brain has developed highly specialized areas assign to the analysis of the facial images (Anila & Devarajan, 2012). Face recognition is based on determining the shape and size of jaw, chin, shape and location of the eyes, nose and every other facial attributes. Facial recognition system offers easy storage of templates in database, reduces the statistic complexities to recognize face image and involves no physical contact with the system (Anadi, 2015).

Facial scanners read face geometry and records it on the grid which is transferred to the database in terms of points. The comparison algorithms perform face matching and come up with the results. Facial recognition is performed in the following ways; facial metrics (the distances between pupils or from nose to lip or chin are measured), Eigen faces (process of analyzing the overall face image as a weighted combination of a number of faces) and skin texture analysis (the unique lines, patterns, and spots apparent in a person's skin are located) (Anadi, 2015). Face recognition and verification system consist of three stages; (a) face localization and segmentation, (b) normalization (c) feature extraction and classification (Raghavendra, Ashok, & Hemantha, 2010). Figure 2.7 Shows ways in which face recognition is performed.



(a) Face Localization and Segmentation (b) Normalization (c) Feature Extraction and Classification

Figure 2.7 Stages in Face recognition (Anadi, 2015)

2.3.4 Fingerprint Recognition

Fingerprints are the patterns present on a finger. It is an impression from the friction ridges of a human finger producing an epidermal layer of the finger which displays some typical characteristics classified as valleys (furrows) and ridges. At a local or fine level, the characteristic of ridges and valleys are known as minutiae (Gnanasivam & Muttan, 2010). A minutia is a collection of ridge ending and ridge bifurcation features of a fingerprint. Ridges are the uniqueness of a fingerprint through their characteristics and relationship with their neighbouring ridges. Figure 2.8 shows the minutia features of a fingerprint. The black lines represent the ridges which are the upper skin layer segment of the fingerprint, the white lines represent the valleys which are the lower segment. The minutiae feature also consist of ridge ending (where a ridge ends) and also bifurcation (where a ridge splits into two). These extracted features provide high efficiency in fingerprint recognition.

Fingerprint is the most commonly used human trait for authentication and identification of individuals amongst all biometrics because of its uniqueness and permanence. It is the most accurate biometric traits with a probability of 1 in 1.9×10^{15} for two fingers to be the same (Chaurasia, 2012). Fingerprint recognition system as shown in Figure 2.9 requires the comparison of an individual's fingerprint with all the fingerprints previously stored in the database. It compares the several features of the print pattern which are aggregate characteristics of the minutia points (Shoewu & Idowu, 2012). The process is divided into two stages: the enrolment stage which consist of acquisition of fingerprint images through the biometric sensor, extraction of features of acquired images and finally storing extracted features into the database. The second stage which is the authentication stage has similar process with the enrolment stage, only that the extracted features, instead of being stored in the database, it is being matched with the stored image features in-order to get a result.

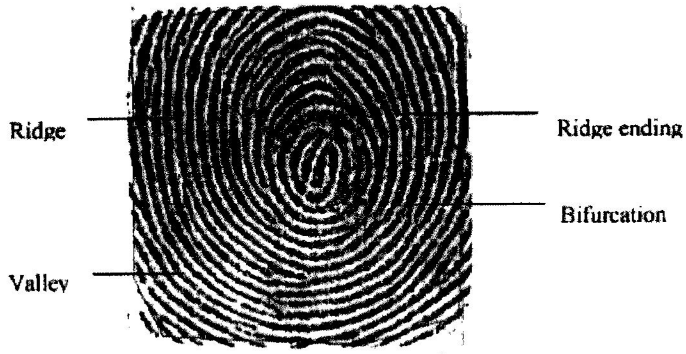


Figure 2.8 Minutiae features of a fingerprint (Jain, Ross, & Prabhakar, 2004)

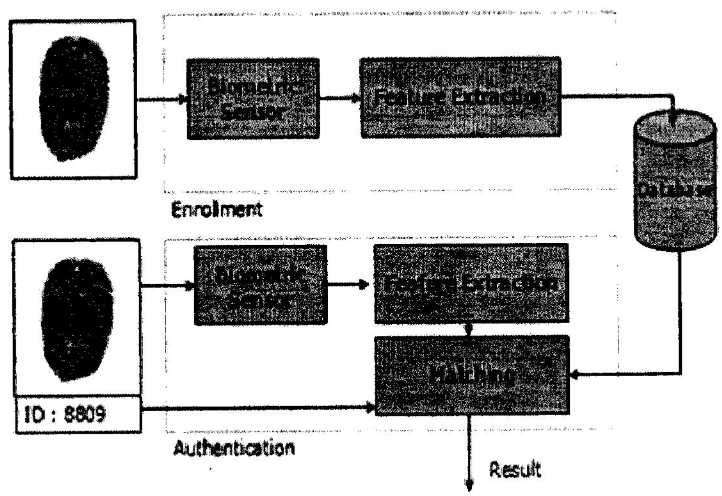


Figure 2.9 Fingerprint recognition process (Shoewu & Idowu, 2012)

Considering Table 2.1 which shows the various biometric traits of human, it is believed that fingerprint is the best and most accepted unimodal biometric trait that can be used for identification and verification. "Fingerprints are one of the basic and most popularly used form of identification. Fingerprints of every person is unique and inalterable" (Mishra, Mishra, Nayak, & Panda, 2016).

2.4 Image Processing

Image processing is a method of performing some operation on an image in order to improve the pictorial information for human interpretation, process it for storage, transmission and representation for autonomous machine perception. It deals with applying mathematical and logical operations on input image so that the output image is better than the input. Image processing is divided into stages such as;

i. Image acquisition (getting of image)
ii. Image enhancement (bringing out the detail that is obscured)
iii. Image restoration (also deals with image appearance improvement)
iv. Morphological process (deals with tools for extracting useful image components)
v. Segmentation (partitioning of image into its constituent part)
vi. Representation and description (raw pixel data, constituting either the boundary of a region or all the points in the region itself)
vii. object recognition (deals with assigning label to an object base on description)

Figure 2.10 shows the continuum from image processing to computer vision which is broken into low – level process, mid – level process and high. When an acquired image is distorted, there is the need for image pre-processing before further image processing is carried out.

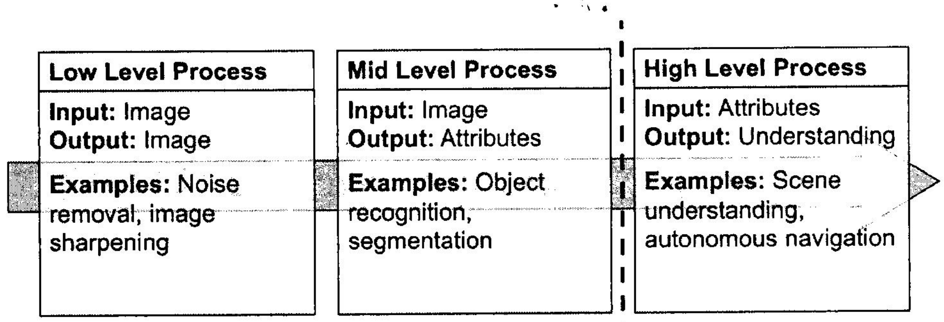


Figure 2.10 Continuum from image processing to computer vision (Gonzalez & Wood, 2012)

2.4.1 Image Pre-processing

Image pre-processing is the operation performed on an image at the lowest level of abstraction whose input and output are image. The purpose of pre-processing is to enhance the quality of images, and also to improve distorted images. In image processing, when a distorted image is acquired, the pre-processing process begins by firstly converting the image to greyscale image (if image is in coloured form), the greyscale image is then converted into binary image because binary images are easy to process.

Image pre-processing can be divided into the following steps:

i. **Binarization:** This is the conversion of grey scale image into binary image because binary images are easy to process.
ii. **Central Line Thinning of the Image:** The next step after binarization is thinning. In order to produce a better result, a central line thinning algorithm is preferred to other types of thinning algorithm.
iii. **Dilation of Thinned Image:** This step is to make images smoother by filling up the edges and holes present in the image.
iv. **Thinning of the Dilated Image**: This step is the same as that of step 2, only that the thinned image at this stage is the dilated image.
v. **Removing Unwanted Portions from the Image (Refining):** There might be some unwanted portion (usually consist of around 20 to 25 pixels) that may lead to incorrect minutiae detection. This step is to remove this unwanted portion by first locating all the connected components present in the image.
vi. **Producing Dual Image:** Fingerprint has a typical characteristic known as duality (i.e. ridges and valleys are dual of each other). For instance, if there is ridge end (considering the ridge end), then there must be a bifurcation (considering the valley) near to it.

If the above steps are followed as stated, the images produced will be very clear and identification of minutiae will be easy (Chaurasia, 2012). Figure 2.11 shows the steps involved in image preprocessing.

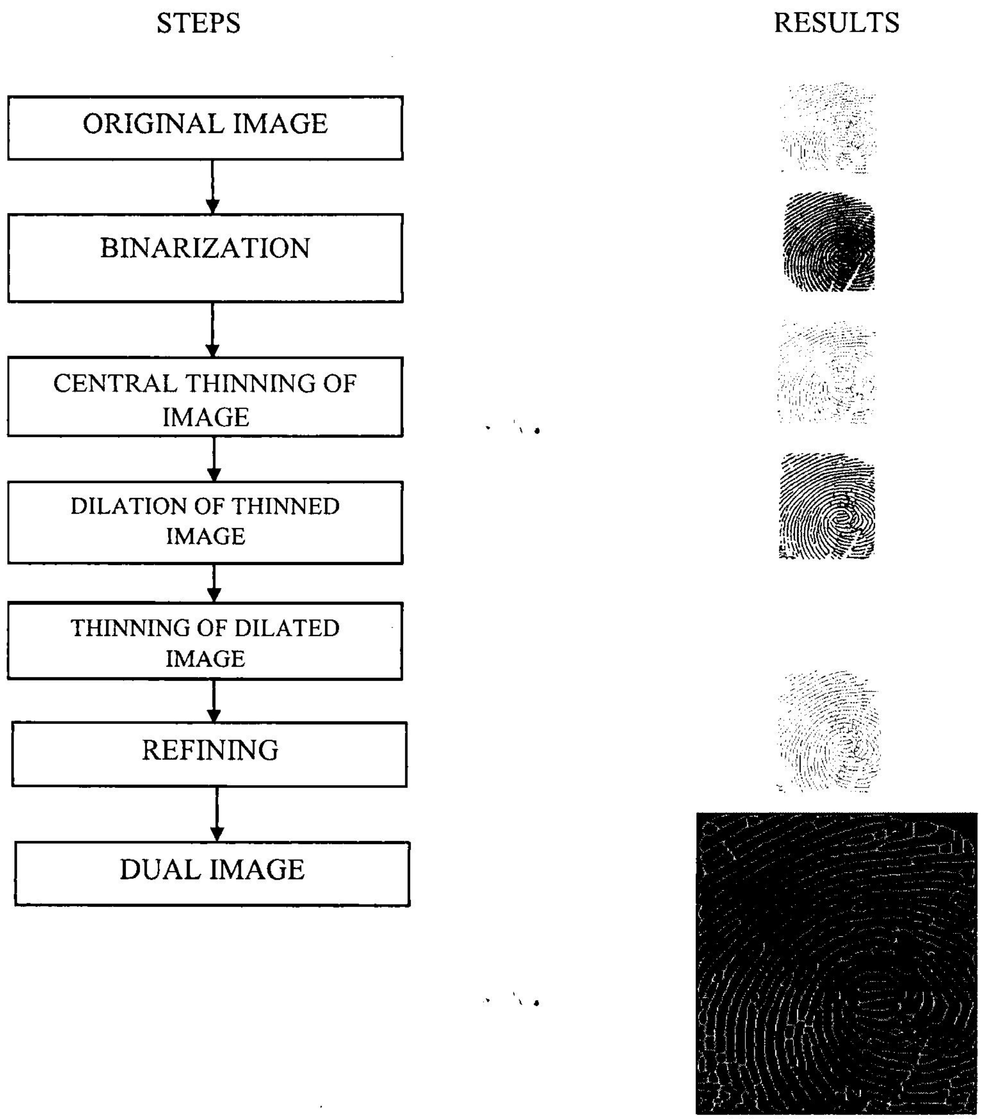


Figure 2.11 Steps in Image Pre – processing (Chaurasia, 2012)

2.5 Feature Extraction

Feature extraction is the process of transforming an input data into a set of features that can represent the input data in a better form. Feature extraction plays a vital role in the area of image processing. It describes the relevant shape information contained in a pattern. The main goal of feature extraction is to obtain the most relevant information from the original data and represent the information in a lower dimensionality space (Kumar & Bhatia, 2014).

In character recognition system, feature extraction is done after the image acquisition and pre-processing phase. Feature extraction approaches include Linear Discriminant Analysis

(LDA), Minutiae Fingerprint Matching, Gabor wavelets, Fast Principle Component Analysis (FPCA) among others.

2.5.1 Linear Discriminant Analysis (LDA)

Linear Discriminant Analysis is a statistical approach for classifying samples of unknown classes based on training samples with known classes. LDA is used to separate samples of distinct groups by minimizing their within – class variability while maximizing their between – class separability (Omidiora, Fakolujo, Ayeni, & Adeyanju, 2008). LDA feature extraction can be carried with the following procedure:

i. Calculate the within class scatter matrix
ii. Calculate the between class scatter matrix
iii. Solve the generalized eigenvalue problem
iv. Keep first C – 1 eigenvectors
v. Project images onto Fisher basis vectors

This technique faces small sample size problem that arises where there are small number of available training samples when dealing with high dimensional data compared to the dimensionality of the sample space. Figure 2.12 shows example of six classes using LDA

Figure 2.12 Example of classes using LDA (Omidiora, Fakolujo, Ayeni, & Adeyanju, 2008)

2.5.2 Latent Semantic Analysis (LSA)

Latent Semantic Analysis (LSA) is a statistical method of feature extraction originally used in the field of Artificial Intelligence branch of Neural Language processing to analyse the data as plain text or document. It can also be used to process image data to form a new image decomposition of the initial matrix into three matrices which are correlated. The technique is then called by the Singular Value Decomposition (SVD).

$$X = USV^T \tag{2.1}$$

Given that X is a matrix whose feature vector are of size I x m (where I and m are total grey level and total image respectively), U is a matrix orthonormal I x m, S is the m x m diagonal matrix, and V are orthonormal m x m. The result of the matrix U from the eigenvectors of matrix multiplication is $X.V.S^{-1}$. While that of V matrix is $X^T.X$.

The S diagonal matrix will contain the eigenvalues of the matrix of V^T orthonormal eigenvectors with a sequence starting from left to right, from the largest eigenvalue to the lowest. After the third matrix is obtained, then the reduction in number of r – dimensional matrix as a vector which will produce the U_k, S_k and V_k^T matrix. In order to generate the Q feature vector matrix with K or n – dimensional, use the formula:

$$Q = Q^T.U_k.S_k^{-1} \tag{2.2}$$

Where S_k^{-1} is a diagonal matrix inverse, and Q^T is a new feature vector transpose matrix (Pratiwi, 2012).

2.5.3 Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a mathematical procedure which uses an orthogonal transformation to convert a set observations of possible correlated variables into a set of values of uncorrelated variables called principal components (Kumar & Bhatia, 2014). PCA is referred to as one of the most important results from applied linear algebra and its most common use is as the first step in trying to analyse large data sets. Some of the other common applications include; de-noising signals, blind source separation, and data compression. PCA is used abundantly in all forms of analysis (Shlens, 2003). PCA method is a global feature selection algorithm which first proposed by Hotteling (1933) as a way to reduce the dimension of a space that is represented in statistics of variables (x_i, i = 1,2,...n) which mutually correlated with each other.

During its development, PCA algorithm (also called the Hotteling transformation) can be used to reduce noise and extract features or essential characteristics of data before the classification process. Election of global feature selection technique in this case because the images will be classified to have relatively low frequency (low level), so the PCA method is quite suitable to be applied.

The steps in the PCA algorithm namely;

i. Create a matrix $[X_1, X_2, \ldots X_m]$ which representing N^2 x m data matrix. X_i is the image of size N x N, where N^2 is the total pixels of the image dimensions and m is the number of images to be classified.

ii. Use the following equation to calculate the average value of all images:

$$Y = \frac{1}{m}\sum_{i=1}^{m} X_i \tag{2.3}$$

iii. Calculate the difference matrix:

$$\overline{X_i} = X_i - Y \tag{2.4}$$

iv. Use the difference matrix obtained previously to generate the covariance matrix to obtain correlation matrix.

$$\Sigma = \sum_{i=1}^{N} \overline{x_i}\, \bar{x}_i^T \tag{2.5}$$

v. Use the correlation matrix to evaluate the eigenvector:

$$\Sigma\, \emptyset_i = \lambda \emptyset_i \tag{2.6}$$

Where $\emptyset$ is orthogonal eigenvector matrix,.λ is the eigenvalue diagonal matrix with diagonal elements sorted ($\lambda_0 > \lambda_1 \ldots \lambda_{N}^{2-1}$ and $\lambda_0 = \lambda_{max}$), which aims to reduce the eigenvector matrix from using the feature space $\emptyset$.

The order of eigenvectors with the largest eigenvalue represents the data closer or similar to the original data

$$\Phi = [\emptyset_1 | \emptyset_2 | \ldots | \emptyset_n] \tag{2.7}$$

Where, $1 \leq n \leq N^2$.

vi. If Φ is a feature vector of the sample image X, then:

$$y_n = \Phi^T \overline{X_i} \tag{2.8}$$

With feature vector y is the n-dimensional (Pratiwi, 2012).

2.5.4 Fast Principal Component Analysis (FPCA)

Fast Principal Component Analysis (FPCA) is one of the most widely used techniques in image recognition. In this technique, some of the features of interest in the fingerprint are used and sub-grouped into the database. Only the sub-grouped fingerprint features are used in the PCA algorithm for recognition. The FPCA procedure consists of taking the sample of the grey scale image in 2D matrix and transforming it into a 1D column vector size N^2 X 1. The image matrix is then placed in the 1D column vector. The column vector of the K image is placed in the columns to form the data matrix Y of dimension N^2 X K. the merit of FPCA is that it is faster and gives accurate fingerprint recognition (Esan, Ngwira, & Osunmakinde, 2013).

$$n = \frac{1}{k}\sum_{i=1}^{k} y \qquad (2.9)$$

The mean n vector of the data vector in matrix K is shown the equation 3.1 above.

Table 2.2 Image extraction algorithm (Zuva, Esan, & Ngwira, 2014)

INPUT:	**Fingerprint image** N
OUTPUT:	**Trained fingerprint**
STEP 1:	**input fingerprint image** N
STEP 2:	**for each** X_1**, compute its projection** $\{u_1\}_1^N = 1 \in R^D$ **for image vector dimension** y
STEP 3:	**compute the weight** W **from each vector**
STEP 4:	**compute the mean vector** m
STEP 5:	**subtract each** X_1 **by** m **to get** φ_1
STEP 6:	**calculate the variance matrix** Σ **of all** φ_1 **(D-by-D) matrix**
STEP 7:	**calculate set of** $\Sigma\,(D-by-N-1)$ **matrix**
STEP 8:	**Preserve the** M **largest Eigen vector based on the Eigen value**
STEP 9:	U_{φ}^T **is Eigen fingerprint representation**

2.5.5 Independent Component Analysis (ICA)

Independent Component Analysis (ICA) is a method of finding latent factors or components from multivariate statistical data. The ICA provides a more powerful representation of the data than PCA because it provides an unrelated representation of the decomposition and irrelevant image. The algorithm computes the major component increments of a vector image sequence without estimating the covariance matrix and, at the same time, transform the main components in a separate address to maximize the source of non – guassianidad (Kamalakumari & Vanitha, 2017). Given a set of observations of random variables, ($x_1(t)$, x_2 (t), … $x_n(t)$), where t is the time or sample index, assume that they are generated as a linear mixture of independent components:

$$\begin{pmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_n(t) \end{pmatrix} = \mathbf{A} \begin{pmatrix} s_1(t) \\ s_2(t) \\ \vdots \\ s_n(t) \end{pmatrix} \tag{2.10}$$

Where A is some unknown matrix. ICA consist of estimating both the matrix A and the $s_i(t)$

2.6 Image Classification

There are various types of algorithms that have been used for image classification, these algorithms include: Artificial Neural Network (ANN), Self-Organization Map (SOM) Neural Network, K – Nearest Neighbour (KNN), Support Vector Machine among others.

2.6.1 Artificial Neural Network (ANN)

Artificial Neural Network is a branch of Artificial Intelligence (AI) and is made up of many artificial neurons which are correlated together in accordance with explicit network architectures. ANN consider classification as one of the most dynamic research and application areas. Neural Network can be used to perform a number of regression and classification tasks at once (Ayodele, 2010).

The objective of the neural network is to convert the inputs into significant outputs. The major disadvantage in using ANN is to find the most appropriate grouping of learning, training, and transfer function for classifying the data sets with growing number of features and classified sets. The strong point of ANN is that the teaching mode can be supervised or unsupervised. Also ANN can learn in the presence of noise (Saravanan & Sasithra, 2014).

2.6.2 Self-Organization Map (SOM) Neural Network

Self-Organization Map (SOM) Neural Network commonly called Kohonen Neural Network is one of the unsupervised learning model that classifies images through the similarity of a particular pattern to the area in the same class. Unlike most networks that are designed for supervised learning task, SOM networks are designed primarily for unsupervised learning. SOM does not utilize the class membership of sample training, it instead uses the information in a group of neurons to modify the local parameter.

The SOM system adaptively classify samples (X images data) into classes by selecting the winning neuron (the on whose center is nearest to the input case), and modifying the weighted neuron to be more like the input case (Pratiwi, 2012). Figure 2.14 shows the architecture of SOM network.

SOM network can learn to recognize data that are in cluster form, and also relate similar classes to each other. As classed of data are recognized, they are labelled so that network will be able to perform the classification task. It can also be used in novelty detection in such a way that, when new data is encountered, the network fails to recognize it and this indicate novelty (Ayodele, 2010). SOM network consist of two layers; the input layer and the output layer as shown in Figure 2.13

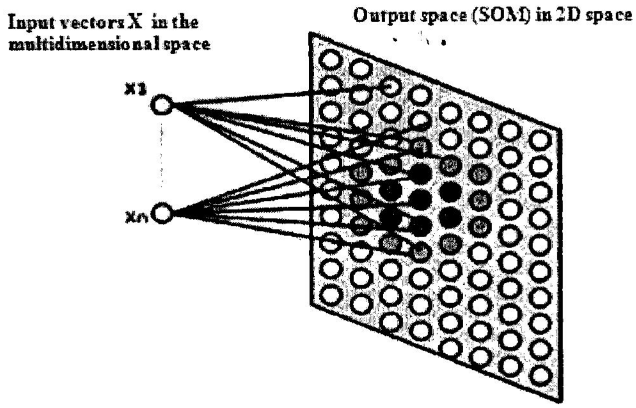


Figure 2.13 Architecture of SOM Network (Pratiwi, 2012)

2.6.3 K – Nearest Neighbour (KNN)

K- Nearest Neighbour (KNN) algorithm used in a database in which data points are separated in different separate classes to predict the classification of a new sample point. That is a new data point can be classified based on known classifications of the observations of a set of data in the database. KNN is used to classify the image of the neighbourhood whose data points proximity can be determine using the Euclidean distance matrix, whereby the distance between all the pixels in a dataset is assigned (known as Euclidean distance between two pixels). The Euclidean matrix is the point Rn in Rn of the function d: Rn and is used to assign

$$N\ x = (X1, \ldots, XN) \qquad (2.11)$$

And

$$Y = \text{any two vectors } (\gamma 1, \ldots, n) \qquad (2.12)$$

This gives the standard between the two vectors Rn, from which the distances are made up of matrices x, y, x, …, The distance between all possible pairs of points (X, Y) (Kamalakumari & Vanitha, 2017).

KNN algorithm can be summarized as:

i. A positive integer K is specified along with the new sample

ii. The K entries in the database which are closest to the new sample is selected

iii. The most common classification of these entries is searched for

iv. The found classification is given to the new sample

According to this scheme, the group of images in the test group is identified by a label of learning set, in which the distance is measured in the nearest point of the assignment. If all the images have been normalized to zero mean and unit variance, then the process is equivalent to selecting the image that is most relevant to the test image in the training set (Sutton, 2012). This process has its limitations.

First, if the images in the training set and the test set are grouped under varying lighting conditions, then the corresponding points in the image space are not tightly grouped. Therefore, this method works reliably under illumination variations, requiring a dense set of learning samples under the continuum of possible lighting conditions. Secondly, it requires a lot of storage space (i.e. training set must contain a large number of images per person). Thirdly, the correlation is computationally expensive. To be recognized, we must correlate the image with the face of each image in the training set to reduce the computational time (Kamalakumari & Vanitha, 2017).

2.6.4 Support Vector Machine (SVM)

Support Vector Machine is linear classification and regression prediction tool that uses machine learning theory to maximize predictive accuracy while automatically avoiding over – fit to the data. SVM uses hypothesis space of a linear functions in a high dimension feature space, trained with a learning algorithm from optimization theory that implements a learning bias derived from statistical learning theory. SVM is one of the most useful techniques for data analysis, pattern recognition and image classification (Jayaram, Prashanth, & Taj, 2015).

It performs classification by constructing an N-dimensional hyper plane that optimally separates the data into two categories.

The goal of SVM modelling is to find the optimal hyper plane that separate clusters of vector in a way that cases with one category of the target variable are on one side of the plane and cases with the other category are on the other side of the plane. The vectors closer to the hyper plane are the support vector (Ayodele, 2010). The SVM cannot be defined when the feature vector of the sample is missing an item application. This system has an advantage of realizing the better performance generalization (Kamalakumari & Vanitha, 2017). Figure 2.14 shows the process of classification using SVM.

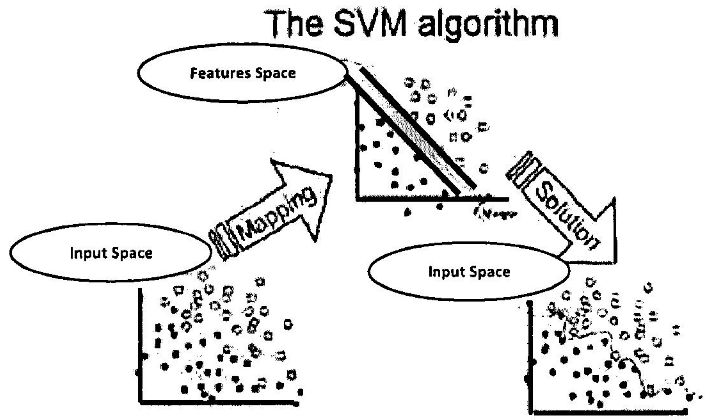


Figure 2.14 SVM classification process (Ayodele, 2010)

2.7 Related Work

Several researchers have proposed different means of identification and verification of an individual, while some proposed the use of smart cards, RFID, others proposed the usage of biometrics traits for identification and verification. While some proposed the use of unimodal biometrics, others proposed multimodal biometric system to achieve this purpose. Unimodal biometrics system makes use of a single biometric trait while multimodal uses the combination of more than one biometric traits of an individual for identification and verification process which are vital for attendance system.

Omidiora *et al* (2008) proposed the recognition of faces with black features (with and without tribal marks) as against the regular non-black face features making use of Optimised Fisher Discriminant Analysis (OFDA) also known as Linear Discriminant Analysis (LDA). Black African faces of different sizes of gray scale images were used for the study, obtaining performance accuracy of between 88 and 99%. This analysis has been used successfully as a statistical feature extraction technique in various classification problems. Omidiora *et al* (2008) made use of 46 black Africans with each person having 10 images from different face views, lighting and expression, out of which 6 best were selected per person. Images were cropped using Microsoft Office Picture Manager in order to have a 102X127 and

104X167 pixels without distortion. The implementation of the face recognition system was tested on an AMD Duron system board with 1.16 GHz processor speed. The total of 276 images were used for the experiment out of which 184 were used in training the database and 92 for testing the created database. This project was faced with some challenges such as not be able to identify images. The major challenge faced in this proposed work was that images that were not properly centered frontally could not be identified due to the fact that cropping it could not remove the background efficiently.

Agulla *et al* (2009) proposed the use of bimodal biometrics for online Learning Management Systems (LMSs) using face and fingerprint as means of identification. LMSs session logs include information about when a resource is being used and about browser events, providing information of when itis in foreground or background. One of the challenges in current LMSs is inadequate tools to properly track the behavior of the users in the system as it only store information about when a user gets an e-learning resource, it has no reliable mechanism to obtain accurate information of the user attendance, such as how much time he/she spends attending a given resource, telling if a user is who he/she claims to be or whether the user is actually in front of the computer or not. The introduction of biometric system allows the tracking of user activity and assessment of user's identity. Detailed session logs from the LMS are combined jointly with a biometric log obtained.

The use of non-collaborative face tracking and recognition as a means of identification and verification in LMSs is faced with some challenges such as bad light conditions in the student room that can lower the verification performance. Human factors can as well degrade the performance of such a system: some users will sit looking at the screen almost all the time, but many others could adopt a non-convenient pose for face verification, blocking the face, looking down to read or write notes, etc. The use of fingerprint verification (collaborative approach) to solve this identification problem however has its own limitation. For instance, once the user is verified using fingerprint, it would be very easy to cheat the system if no user tracking is performed (Agulla, Rua, Castro, Jimenez, & Rifon, 2009). After considering the challenges in using either non collaborative face tracking and recognition or collaborative fingerprint verification, Agulla *et al* (2009) proposed the combination of both biometrics-based log to obtain a single multimodal log such that once the system is unable to determine the identity of a user due to light condition for instance, the fingerprint verification would be used and vice versa. One of the challenges of this proposed form of identification and verification is its limitation to online Learning Management Systems (LMSs) only.

Wambugu (2011) in his work proposed the design of attendance system using smart card in-order to ease the process of monitoring how students attend lectures. The work analyses the system in term of student registration, smart card insurance and smart card usage for recording attendance. The work was implemented using smart card reader and smart card for the hardware part, while MySQL DBMS were chosen for data storage and Java programming language for program design. This system is also faced with the same limitation as that of RFID.

Mishra & Trivedi (2011) proposed fingerprint recognition and one – to – many matching for student attendance system that would effectively manage attendance of students at institutes. Their aim was to improve fingerprint identification system for implementation on large database. Several new algorithms such as gender estimation, key based one – many matching, removing boundary minutiae were used in their proposed work, which enabled them to develop an identification system that is faster in implementation than other available ones. The system was implemented using MATLAB10, Intel Core2Duo processor.

Chaurasia (2012) proposed the use of all existing algorithms to process fingerprint images. This approach has six steps to be performed successively; (1) Converting the given grey scale image to binary image (Binarization). (2) Central line thinning of the image. (3) Dilation of the thinned image. (4) Thinning of the dilated image. (5) Removing unwanted portion of the image (Refining). (6) Producing dual image. It was discovered that if an image is processed following the steps stated, then the final output will be good enough for minutiae detection and feature extraction. This image pre-processing process is however limited to fingerprint images captured with a good quality device due to the fact that image quality enhancement was not added to the process.

Suton (2012) proposed the use of K – Nearest Neighbor (KNN) algorithm for image classification in order to use a database in which the data points are separated into classes to predict the classification of a new sample point. The characteristics of each images were considered during the training set as a different dimension in some space whose observed values were taken as its coordinate in that dimension. Then, the similarity of two points was considered the distance between them in the space under appropriate metric.

Nainan *et al* (2013) proposed an attendance management system using RFID whose implementation was further elaborated on by Hussain *et al* (2014) by making use of an Open Source software in a multi – user environment. The system was developed using python as backend for tags. A JAVA based desktop application was used for lecturers' authentication. The codes and record tags were compiled in XML which was uploaded in the server for processing and interpretation of students' attendance.

Zuva *et al* (2014) proposed the hybridization of bimodal biometrics for access control authentication, making use of fingerprint and face as the distinctive human biometric traits for their project. The aim of their proposed work is to improve the performance of authentication system. Modified Gabor Filter (MGF) and Hierarchal Structure check system model where hybridized to improve quality, enhance and optimize the noisy, distorted or misaligned fingerprint (produced as 2D on x, y image). While Fast Principal Component Analysis (FPCA) algorithm was used to improve recognition accuracy of distorted face as a result of lighting, pose, head orientation, blurriness and other conditions. Futronic fingerprint scanner and canon digital camera were used to capture fingerprint and face images respectively, with the practical work of image alignment and recognition carried out using MATLAB.

Htwe *et al* (2015) proposed the use of RFID card and fingerprint sensing circuit to design and implement a bank locker security system, while the challenges of taking school attendance manually such as difficulty in keeping the attendance list for a long time, improper documentation, students forgetting to write or sign the attendance paper among many others was what prompted Olanipekun and Boyinbode (2015) to propose the use of Radio Frequency Identification (RFID). This proposed technology provides the functionalities of registering students, recording attendance, making decision on the eligibility of a student to sit for an examination in a course and other functions. The RFID based automatic attendance system consist of the RFID reader responsible for detecting tags that are within frequency range, RFID tags which is connected to the student to be monitored, computer system and host application. The system automatically takes students' attendance and alerting them of low attendance when the need arises.

Kumar & Manimozhi (2015) developed an authentication system using an Embedded Smart ID Card (ESIC) interfaced with android platform. The system was designed in a way that smart card with biometric trait was connected through wireless communications and interfaced to android phone/laptop. The card was deliberated by 32 bit RISC secure microcontroller with EEPROM; Material of card body can be PVC/PET/Polycarbonate with biometric features connected through Wi – Fi/Bluetooth to Android phone/laptop through android app or through windows app respectively.

Hasan (2015) developed a web based attendance management system that can be implemented on any computer in order to overcome to overcome the problems of manual attendance. PHP was used as server side language, MySQL and PHP were used as back-end design while HTML, CSS and JavaScript were used as front-end tools. The system interacts with the database created and it automatically calculates the attendance percentage of each student. It also facilitates the end users with interactive design and automated processing of attendance management. This attendance system has its limitation has it depends on internet for it function.

Mishra *et al* (2016) proposed the use of Self Organization Feature Map (SOFM) for the classification and matching of fingerprint in order to reduce run time complexity and increase the performance of using whorl, left and right loop, arch and tented arch for extraction and minutiae matching for verification and identification operation on the fingerprint. The images of fingerprint were enhanced through the following steps: Histogram Equalization (to improve global contrast of the image), Fast Fourier Transformation (to improve the specific block of the image subdivided into small processing blocks by its dominant frequency values), Binarization (to transform 8-bit gray image to a 1-bit image having the value 1 for furrows and 0 for ridges), Thinning, Block Direction Estimation, Morphological Operations, Image Segmentation and Core Point Extraction. From the result of their work, it is believed that SOM algorithm can be used for large scale of verification and identification operation efficiently and with less time complexity.

Adeyanju *et al* (2016) also proposed the application of an improved Self Organization Feature Map (SOFM) and Modified Counter Propagation Network (CPN) techniques to improve face recognition performance. The threat to global peace and criminal activities in the society prompted them to make use of these two artificial neural network techniques. Six face images were captured from 40 African individuals with a digital camera, totalling 240 face images stored in a database. Image pre-processing was carried out using MATLAB and normalized using local histogram equalization for contrast enhancement. Image reduction and feature extraction was carried out using Principal Component Analysis

(PCA), while SOFM and CPN were used for classification. Images were reduced from 600 x 800 four different dimensions; 50 x 50, 100 x 100, 150 x 150, 200 x 200. Out of the 240 images acquired, 140 were used to train and the remaining 100 images to test the system. The result of the project showed that, at 50 x 50 pixels, SOFM had 81% accuracy (within the time of 243s), while CPN had 84% accuracy (within the time of 174s). At 100 x 100 pixels, SOFM had 83% accuracy (within the time of 244s), while CPN had 88% accuracy (within the time of 179s). At 150 x 150 pixels, SOFM had 87% accuracy (within the time of 245s) while CPN gave 90% accuracy (within 190s). Finally, at 200 x 200 pixels, SOFM gave 92% accuracy (in 249s), while CPN gave 95% accuracy (in 234s). From these results, it is shown that CPN is better compared to SOFM techniques in face recognition.

The use of RFID was further proposed by Moharil *et al* (2016) in conjunction with fingerprint technique, who on the other hand used it to improve attendance management of staffs in-order to control labor cost, minimize compliance risk and improve workforce productivity. It also reduces the administrative time associated with attendance exceptions and employee inquiries (Moharil & Dandare, 2016). The algorithms and programs were developed using python for the Raspberry pi 2 Model B. GSM/GPRS module was used to alert every affected individual. Although, this proposed method eradicate the deficiencies associated with the manual attendance system, it is faced with challenges such as impersonation i.e student swiping another student's RFID tag to register his/her attendance, missing tag implying that student is absent from class among others.

Falohun *et al* (2016) proposed the use of bimodal biometric system considering iris and fingerprint as the human traits required for identification and verification which was further emphasized on by Charity *et al* (2017), who proposed the fusion of fingerprint and face biometrics for student attendance system in order to improve the recognition accuracy of automated student attendance systems. They made use of face and fingerprint as the required human traits stating the drawbacks of using unimodal biometric systems.

"Using more than one biometric has made it possible to eliminate most of the drawbacks of unimodal biometric systems" (Charity, Okokpujie, & Etinosa, 2017). The above stated drawbacks among many others prompted them to propose the use of bimodal biometrics (fingerprint and face) attendance system using the logical technique OR such that when one of the traits is affected by either of the possible drawbacks, the other trait will be available for the attendance system to function, and when both traits are not affected the recognition accuracy tends to be high as they recorded a minimum recognition accuracy of 87.83% on the implementation of their proposed system. Their proposed system made use of MATLAB® and MYSQL for image capturing, image processing, feature extraction and classification. Feature extraction was carried out using a combination of Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). Support Vector Machine (SVM) classifier was used for facial recognition, while fingerprint recognition was done by matching minutiae.

Saheed *et al* (2017) proposed the use of fingerprint as a biometric means for Examination Clearance in Higher Institution. This biometric technique reduces the risk of lost, forgotten or copied password. This system was developed to overcome the defects of using paper clearance approach such as fraud, malpractices impersonation and other unlawful act during examination. The system function in a way that a student is identified after comparing his/her fingerprint with the record in the database. Fingerprint recognition system has the advantages of reliability, error free cost effectiveness, simple to implement and use and availability of user at the point of identification and verification.

Adewale (2017) proposed the development of a bimodal biometric based attendance system using face and fingerprint as a means of identification and verification. Principal Component Analysis (PCA) was used for feature extraction of both facial and fingerprint features, while Euclidean distance was used for feature matching. The outcome of the developed system showed that it has a False Acceptance Rate of 0.83, False Reject Rate of 0.90 and Accuracy of 85.17%. This system solve the problems encountered using traditional method of attendance.

CHAPTER THREE

DESIGN METHODOLOGY

3.1 Overview of the Fingerprint Based Students' Attendance System

This attendance system is a unimodal biometric system. It was developed using fingerprint as the unique physiological trait of an individual. This attendance system involves the following processes: data acquisition, image preprocessing, feature extraction, image classification, evaluation and decision. These processes were carried out using MATLAB R2015a. Figure 3.1 shows the block diagram of the proposed fingerprint based students' attendance system.

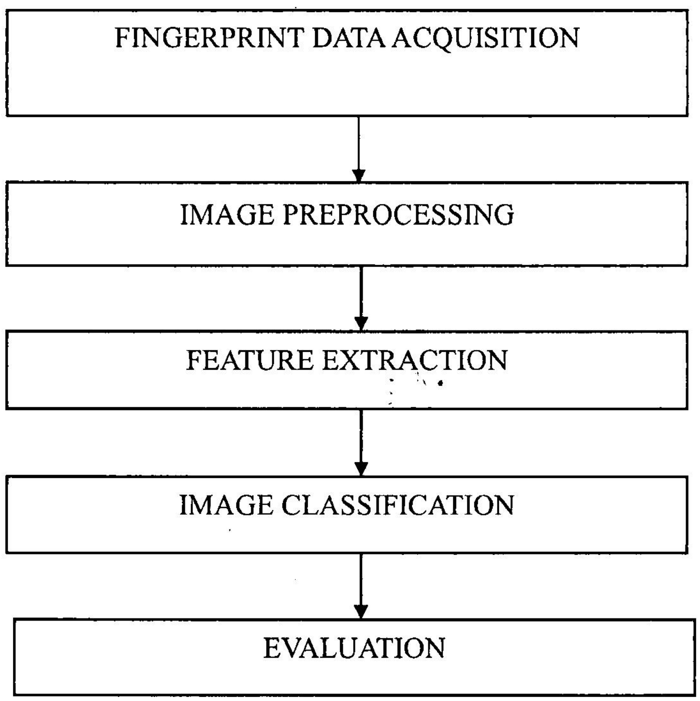


Figure 3.1 Block Diagram of the Fingerprint Based Students' Attendance System

3.2 Fingerprint Data Acquisition

Fingerprints of forty – four (44) participants were captured using DigitalPersona scanner as fingerprint sensor. The participants were students of Federal University Oye – Ekiti, Ekiti State, Nigeria. These fingerprints were acquired through the fingerprint sensor and then proper processing was done on the acquired images which were stored in the system database. The data acquired was used to train and test the system. The proposed system recognizes an individual by comparing his/her fingerprint with every record in the database.

3.3 Image Pre – processing

The next stage after data acquisition is image pre-processing. Pre-processing was carried on the data acquired in order to improve the quality of images that could be affected as result variations in environmental conditions, skin conditions and fingerprint sensor. Steps involved in image preprocessing include gray scale, binarization, central line thinning of the image, dilation of thinned image, thinning of dilated image.

Image pre-processing techniques was applied on the sampled images, after which, feature extraction technique was applied to get the useful features. Considering Figure 3.2 which displays a fingerprint sample of an individual that is to undergo image pre-processing.

Figure 3.2 Fingerprint Sample

The following are the steps carried out for image pre-processing:

i. **Gray Scale conversion:** This is the process of converting acquired images from colored (3D) form into gray (2D) form. Although some image formats (e.g bmp) may appear to be in black and white form to the human eye, it still requires to be gray-scaled in-order to achieve desirable result. Gray scale can be performed on sample images through **"rgb2gray(image1)"** command line of code. Gray – scaling of image sample of Figure 3.2 results into image shown in Figure 3.3 below:

Figure 3.3 Result of a Gray-scaled Image

ii. **Binarization:** Most extraction algorithms operate on basically binary images where there are only two levels of interest: the black pixels represent ridges, and the white pixels represent valleys. Binarization is the conversion of grey scale image into binary image such that the values below a given threshold is regarded as binary "0", while values the equals or is above the given threshold is regarded as binary "1". It is performed with **"im2bw (image2, 0.5)"** command line. This helps in improving the contrast between the ridges and valleys in a fingerprint image, and consequently facilitates the extraction of minutiae. The binarization (with 0.5 as threshold) of gray – scaled image (Figure 3.3) results into image shown in Figure 3.4.

Figure 3.4: Result of a Binarized Image

iii. **Central Line Thinning of the Image:** The next step after binarization is thinning. This is a morphological operation used to remove selected foreground pixels from the binary image. Thinning reduces the ridge thickness to one pixel wide. In order to produce a better result, a central line thinning algorithm is preferred to other types of thinning algorithm. The command for thinning an image is given as **"edge (image3, 'canny', TS)**. where TS is a threshold that is assigned the value of 0.6 for this project. The outcome of thinning binarized image is shown in Figure 3.5 below:

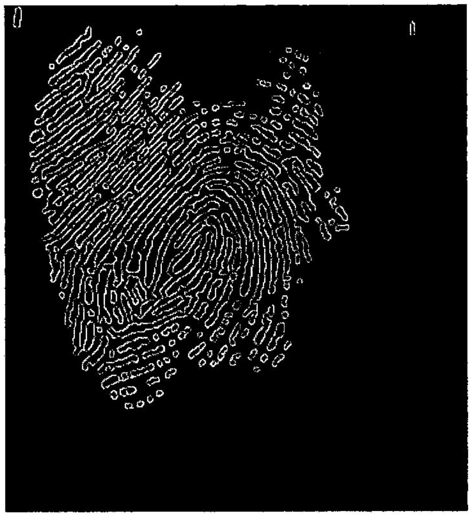


Figure 3.5: Result of a Thinned Image

iv. **Dilation of Thinned Image:** This step is to make images smoother by filling up the edges and holes present in the image. The result of dilating a thinned image is shown in Figure 3.6 below:

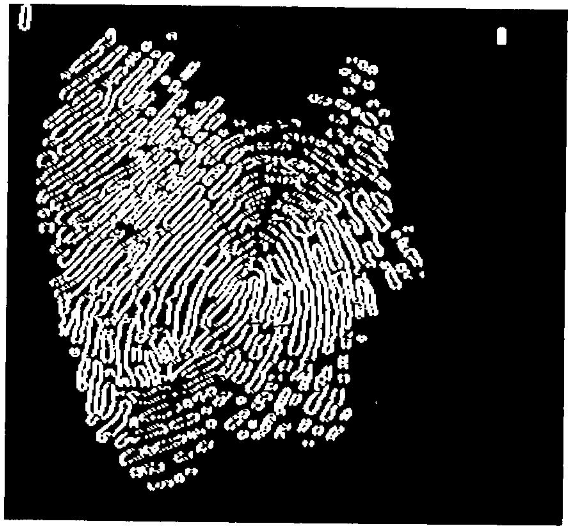


Figure 3.6: Result of a Dilated Thinned Image

v. **Thinning of the Dilated Image**: This is the last step that was carried out in image pre-processing before features extraction process. This step is the same as that of step 2, only that the thinned image at this stage is the dilated image. The result of further thinning dilated sampled image is given in Figure 3.7 below:

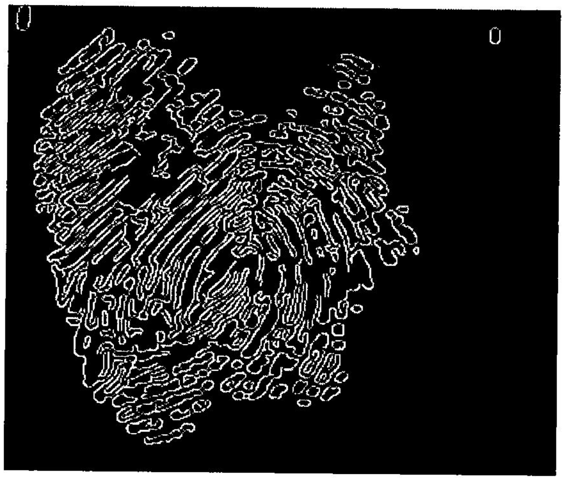


Figure 3.7: Result of a Thinned Dilated Image

3.4 Feature Extraction with Minutiae Matching

Feature extraction is the next step after image quality has been improved. Extraction of appropriate features is one of the most important task in recognition system. Feature extraction is the process of transforming an input data into a set of features that can represent the input data in a better form. The main goal of feature extraction is to obtain the most relevant information from the original data and represent the information in a lower dimensionality space. The feature extraction technique that was used for this project is the Minutiae Matching. The major feature that was extracted from the fingerprint image is the minutiae patterns which are the relevant shape information contained in a fingerprint. Transformation of input minutiae set is the most important step in order to maximize the value of similarity score (Lukasz, 2014). Figure 3.8 below shows the minutiae base matching of a fingerprint.

$$S(T, I) = \max\{ \forall_m \sum_{i=1}^{n} md(m_i, map_m(m_i'))\} \tag{3.1}$$

$$md(m_i, m_j) = sd(m_i, m_j) \,.\, dd(m_i, m_j) \tag{3.2}$$

Where:

n is the number of minutiae points in the *I* input set, and

m is the number of transformation equal to the number of minutiae in *T* template set

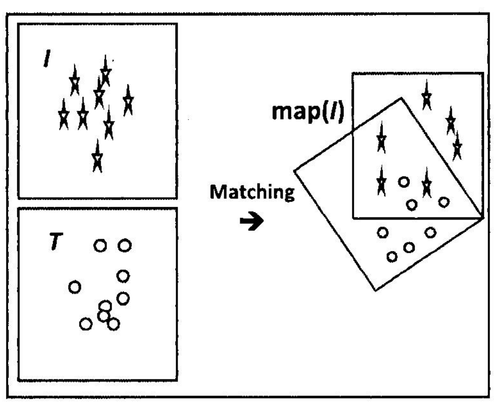


Figure 3.8: Minutiae Base Matching (Lukasz, 2014)

Minutiae matching is one of the most commonly used algorithms for extracting features that characterizes a fingerprint. These minutiae feature locations and type were stored in the biometric template and used to identify different individual. The most commonly employed method of minutiae extraction is the Crossing Number (CN) concept. This method involves the use of skeleton image where the ridge flow pattern is eight-connected. The minutiae are extracted by scanning the local neighbourhood of each ridge pixel in the image using a 3 x 3 window. After which the CN value is computed, which is defined as half the sum of the differences between pairs of adjacent pixels in the eight-neighbourhood (Chaurasia, 2012). The ridge pixel can then be classified as ridge ending, bifurcation or non-minutiae point. For instance, a ridge pixel with a CN of one corresponds to a ridge ending, and a CN of three corresponds to a bifurcation as shown in Figure 3.9 (a) and (b) respectively. Table 3.1 shows the properties of Crossing Number (CN).

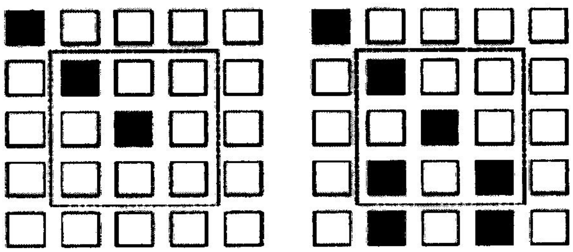


Figure 3.9 Examples of (a) ridge – ending and (b) bifurcation pixel (Chaurasia, 2012)

Table 3.1 Properties of Crossing Number (Chaurasia, 2012)

CN	Property
0	Isolated Point
1	**Ridge Ending Point**
2	Continuing Ridge Point
3	**Bifurcation Point**
4	Crossing Point

3.5 Image Classification and Recognition with Euclidean Distance

The distance between two points defined as the square root of the sum of the squares of the differences between the corresponding coordinates of the points is known as Euclidean distance. These points can be in different dimensional space and are represented by different forms of coordinates. In one-dimensional space, the points are just on a straight number line.

In two-dimensional space, the coordinates are given as points on the x- and y-axes, and in three-dimensional space, x-, y- and z-axes are used. Finding the Euclidean distance between points depends on the particular dimensional space in which they are found. For instance, the Euclidean distance of a two dimensional space whose coordinates are x- and y-axes can be obtained by subtracting the x- and y-coordinates of the first point from the x- and y-coordinates of the second point. For example, the coordinates of the first point are (2, 4) and the coordinates of the second point are (-3, 8). Subtracting the first x-coordinate of 2 from the second x-coordinate of -3 results in -5. Subtracting the first y-coordinate of 4 from the second y-coordinate of 8 equals 4.

Square the difference of the x-coordinates and also square the difference of the y-coordinates. For this example, the difference of the x-coordinates is -5, and -5 squared is 25, and the difference of the y-coordinates is 4, and 4 squared is 16.

Add the squares together, and then take the square root of that sum to find the distance. For this example, 25 added to 16 is 41, and the square root of 41 is 6.403.

Euclidean distance is the most obvious way of representing distance between two points. The Euclidean distance between two is defined as mathematically as:

$$D_e(x,y) = \sqrt{(X_2 - X_1)^2 - (Y_2 - Y_1)^2} \tag{3.3}$$

Where x and y are pixels with coordinates (X_1, Y_1) and (X_2, Y_2) respectively.

3.6 Proposed Performance Evaluation

The performance of the system was evaluated in order to determine the system's effectiveness through visual inspection as well as quantitatively. During visual inspection, one compares the quality of the pixel value of distorted and misaligned fingerprints with enhanced fingerprint images. The following evaluation model was used to evaluate the system:

i. **False Rejection Rate (FRR)**: This is the probability that the biometric system will fail to recognize and mark present in the attendance register a person that was enrolled on the system.

$$\text{FRR} = \frac{\text{Number of False Negative}}{\text{Number of samples in the database}} \tag{3.2}$$

ii. **False Accept Rate (FAR)**: This is the probability that the biometric system will incorrectly recognize and mark present in the attendance a person that was not enrolled on the system or will fail to reject an imposter. It is calculated with the equation below:
Number of false rejection rate.

$$\text{FAR} = \frac{\text{Number of False Positive}}{\text{Number of samples not in the database}} \tag{3.3}$$

iii. **Accuracy**: This is the ratio of the total number of TP, TN, and the total number of test images multiplied by 100

$$\text{Accuracy} = \frac{\text{Numnber of (TP+TN)}}{Number\ of\ (TP+TN+FP+FN)}\ X\ 100\% \tag{3.4}$$

Where

TP: True positive is when a system makes right decision in matching the right fingerprint sample as the right answer.

TN: True Negative is when a system makes right decision by denying a fingerprint sample that is not registered.

FP: False Positive is when a system fails to match a registered fingerprint sample.

FN: False negative is when a system wrongly matches a fingerprint sample that is not registered.

iv. **Execution Time**: The amount of time it takes for the system to run a recognition process

3.7 Hardware Prototype Design

The proteus design and block diagram of the proposed fingerprint based student attendance system are illustrated in Figure 3.10 and 3.11 respectively. The student's bio-data are firstly enrolled in the system database. When student enters into the class, his/her finger is placed on the fingerprint scanner. Once the student fingerprint matches with the one in the database, he/she is marked present for the particular lesson, otherwise, he/she will not be permitted an entrance for the lesson.

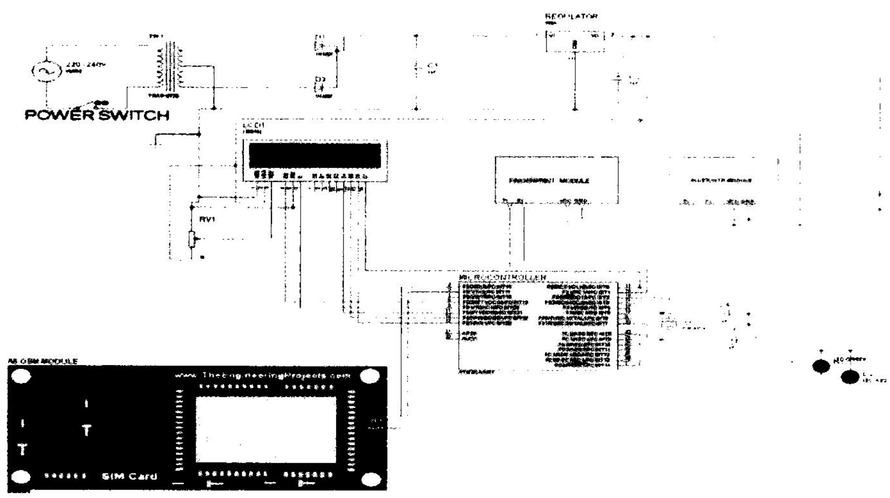


Figure 3.10 Proteus Design of Fingerprint Attendance System

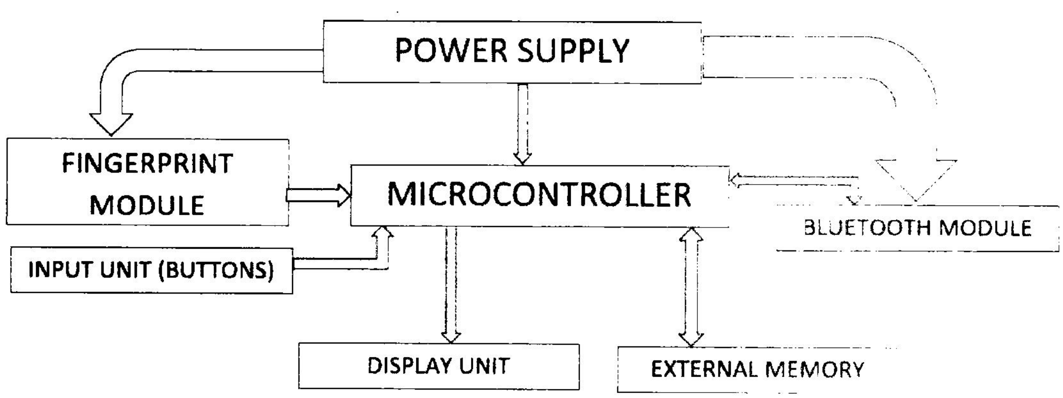


Figure 3.11 Block Diagram of Fingerprint Attendance System

The attendance register system consists of three main components which are registration, attendance tracking and reporting which inter – operates. The operation of each stages of the system is as follow:

i. **Registration**: This stage involves the creation of list of courses that are offered in the department. Details such as the course code and the name of the course are obtained at this stage. The program is used to capture the details of a student and save in the database.

ii. **Recording Student Attendance**: This stage involves creating of lessons for a particular lecturer, the program is then used to capture attendance information. Once a student places his/her finger on the scanner, the program obtains the details assigned to recognized fingerprint. The program verifies that the student is in the right lesson by comparing the list of courses assigned to the fingerprint sample to the course in progress. If a match is found, the student is added to the list of students who have attended that lesson. At the end of the lesson, the attendance data is then compiled.

iii. **Report generation**: This stage creates room for lecturers to log on to the system and view attendance details for courses they are in charge of. The program ensures that the lesson has already ended and then generates a list of students registered for that course, indicating whether they attended that lesson or not.

CHAPTER FOUR

IMPLEMENTATION AND RESULT

4.1 Implementation

The system is developed such that a finger print sample is selected out of the series of samples on the test folder through the select button, it is then compared with the samples on the training folder, the outcome of the comparison will display the validity of the tested fingerprint sample. Figure 4.1, 4.2, 4.3 and 4.4 shows the GUI of the software application which illustrates the default stage, sample selection stage, comparison stage and output result of the system respectively.

i. **Default Stage**: This stage shows the first aspect of the system once the programm is executed. It consists of "DEMO" fingerprint images at both the selected image display and the output image display which implies that it awaits selection of image from the test folder and validation of the selected image. This is illustrated in Figure 4.1 below.

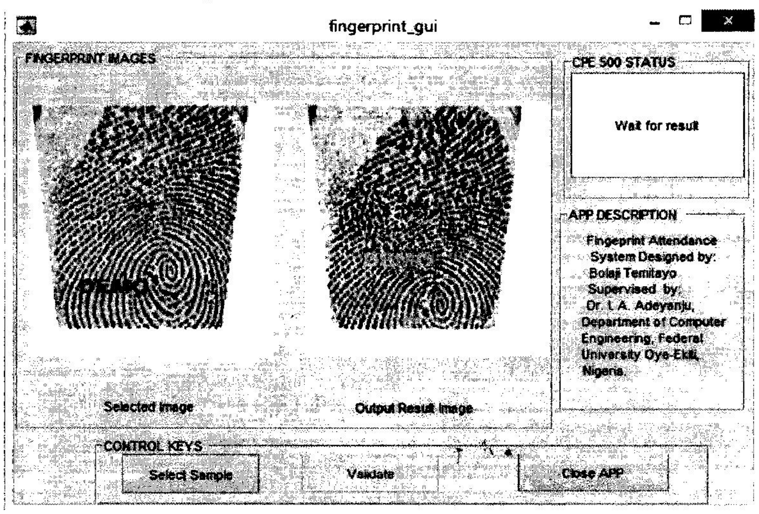


Figure 4.1: GUI of Default Stage

ii. **Sample Selection Stage**: This stage as illustrated in the Figure 4.2 shows series of images in the test folder, out of which one image is selected to test the system against images on the training folder.

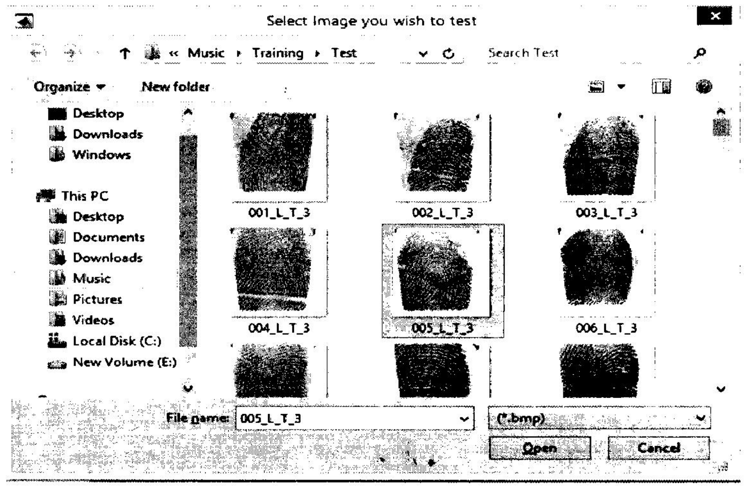


Figure 4.2: GUI of Sample Selection Stage

iii. **Validation Stage**: This stage as shown in Figure 4.3 below is similar to the default stage, the main difference is that the selected sample section displays the fingerprint image that is selected from the test folder and the validate button is activated for validation.

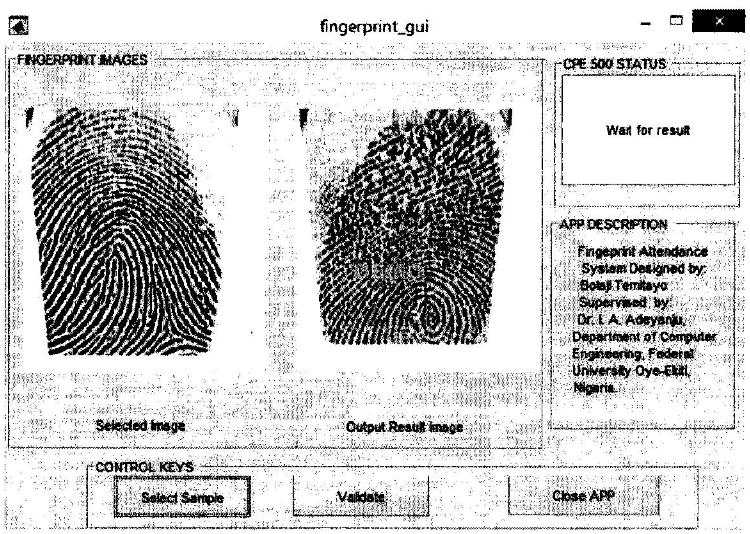
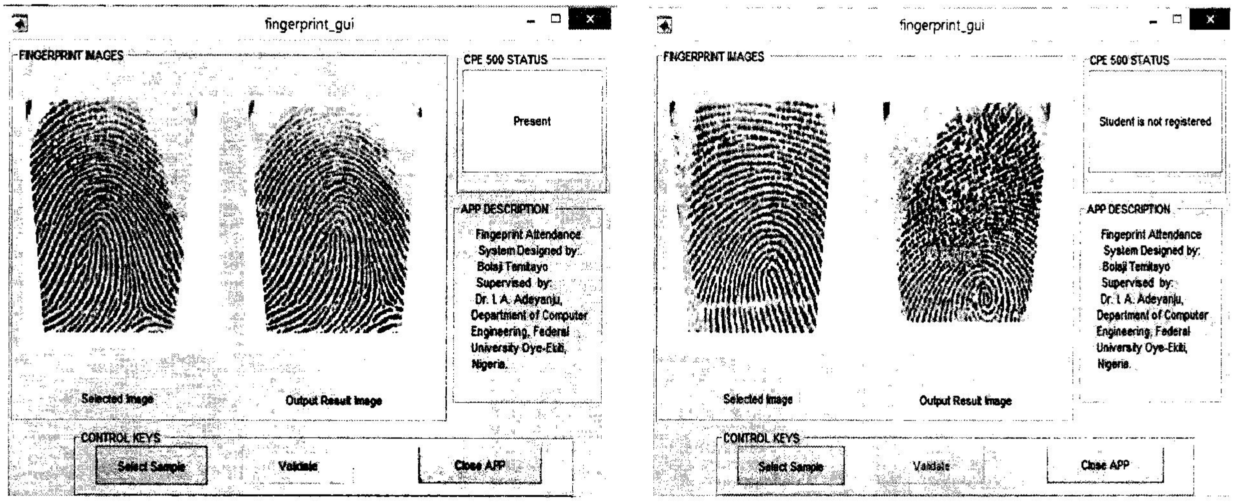


Figure 4.3: GUI of Validation Stage

iv. **Output Result**: This stage displays the outcome of the image validation as shown in Figure 4.4. Once the image selected in the test folder matches one of the images in the training folder, the matched image is displayed at the output result image section and the status section shows "present". Otherwise, the output result image section retains its previous image while the status section shows "student is not registered".



(a) Matched Image (b) Unmatched Image

Figure 4.4: GUI of Output Result

4.2 Experimental Setup

The biometric attendance system was developed using MATLAB R2015a. Fingerprint samples were acquired from forty – four (44) individuals in Federal University Oye – Ekiti, Ikole campus, Ekiti State. Thirty (30) fingerprint samples (i.e. 3 samples per finger) were acquired from each individual. These samples were divided into train and test folder which was used for the evaluation of the system. The training folder contained twenty (20) samples from 42 individuals, while the test folder contained the remaining ten (10) samples from the same 42 individuals. Also contained in the test folders were 30 samples from 2 different individuals whose fingerprint samples were not in the training folder.

4.3 Evaluation Results

The image samples in the test folder were used to test the system. Due to the relatively long execution time each recognition took, only two (2) samples of both left and right thumb from 42 individuals (total of 168 images) were used to create the evaluation training database. While the test datasets consisted of the third sample from both left and right thumb of the same 42 individuals and all three (3) samples of both left and right thumb from the remaining individuals not featured in the training; this makes a total of 96 test images. The threshold for image recognition by the system is 35 i.e. if the distance between an image in the test dataset and the images in the training database is above the threshold, then it is not recognized by the system. The result of the evaluation is shown in the Table 4.1 with the following details: Test Image ID, Recognized Image ID, Prediction, Time of Execution and True Positive (TP)/True Negative (TN)/False Positive (FP)/False Negative (FN)

Table 4.1 System Test Result

S/N	Test Image ID	Recognized Image ID	Prediction	Time of Execution mm:ss.ms	TP/TN/FP/FN
1	001_L_T_3	001_L_T_1	Correct	00:04.9	TP
2	001_R_T_3	001_R_T_1	Correct	00:04.6	TP
3	002_L_T_3	002_L_T_1	Correct	00:04.9	TP
4	002_R_T_3	002_R_T_2	Correct	00:04.7	TP
5	003_L_T_3	003_L_T_2	Correct	00:04.5	TP
6	003_R_T_3	003_R_T_2	Correct	00:04.8	TP
7	004_L_T_3	004_L_T_2	Correct	00:04.7	TP
8	004_R_T_3	004_R_T_1	Correct	00:04.7	TP
9	005_L_T_3	005_L_T_1	Correct	00:05.5	TP
10	005_R_T_3	005_R_T_1	Correct	00:05.1	TP
11	006_L_T_3	006_L_T_1	Correct	00:04.9	TP
12	006_R_T_3	006_R_T_2	Correct	00:04.9	TP
13	007_L_T_3	007_L_T_1	Correct	00:05.0	TP
14	007_R_T_3	007_R_T_1	Correct	00:04.9	TP
15	008_L_T_3	008_L_T_1	Correct	00:04.8	TP
16	008_R_T_3	008_R_T_1	Correct	00:04.7	TP
17	009_L_T_3	009_L_T_2	Correct	00:04.8	TP
18	009_R_T_3	009_R_T_2	Correct	00:04.8	TP
19	010_L_T_3	010_L_T_1	Correct	00:05.2	TP
20	010_R_T_3	010_R_T_1	Correct	00:5.0	TP
21	011_L_T_3	011_L_T_1	Correct	00:05.1	TP
22	011_R_T_3	011_R_T_2	Correct	00:04.8	TP
23	012_L_T_3	012_L_T_1	Correct	00:04.7	TP
24	012_R_T_3	005_R_T_2	Wrong	00:04.9	FP

25	013_L_T_3	013_L_T_1	Correct	00:04.0	TP
26	013_R_T_3	023_L_T_2	Wrong	00:04.9	FP
27	014_L_T_3	014_L_T_1	Correct	00:04.8	TP
28	014_R_T_3	014_R_T_1	Correct	00:04.5	TP
29	015_L_T_3	030_R_T_1	Wrong	00:05.0	FP
30	015_R_T_3	015_R_T_1	Correct	00:04.8	TP
31	016_L_T_3	024_R_T_1	Wrong	00:05.0	FP
32	016_R_T_3	016_R_T_1	Correct	00:05.0	TP
33	017_L_T_3	017_L_T_1	Correct	00:04.9	TP
34	017_R_T_3	017_L_T_1	Wrong	00:04.7	FP
35	018_L_T_3	038_L_T_1	Wrong	00:05.2	FP
36	018_R_T_3	018_R_T_1	Correct	00:05.0	TP
37	019_L_T_3	019_L_T_2	Correct	00:04.8	TP
38	019_R_T_3	019_R_T_1	Correct	00:04.7	TP
39	020_L_T_3	020_L_T_2	Correct	00:04.9	TP
40	020_R_T_3	020_R_T_1	Correct	00:05.0	TP
41	021_L_T_3	021_L_T_1	Correct	00:05.1	TP
42	021_R_T_3	021_R_T_2	Correct	00:04.8	TP
43	022_L_T_3	022_L_T_2	Correct	00:04.9	TP
44	022_R_T_3	022_R_T_1	Correct	00:05.0	TP
45	023_L_T_3	023_L_T_1	Correct	00:04.8	TP
46	023_R_T_3	023_R_T_1	Correct	00:05.1	TP
47	024_L_T_3	024_L_T_2	Correct	00:05.0	TP
48	024_R_T_3	024_R_T_1	Correct	00:05.1	TP
49	025_L_T_3	025_L_T_2	Correct	00:04.6	TP
50	025_R_T_3	029_R_T_2	Wrong	00:04.7	FP
51	026_L_T_3	026_L_T_1	Correct	00:05.0	TP
52	026_R_T_3	026_R_T_1	Correct	00:05.0	TP
53	027_L_T_3	027_L_T_2	Correct	00:05.0	TP
54	027_R_T_3	027_R_T_1	Correct	00:05.0	TP
55	028_L_T_3	028_L_T_1	Correct	00:04.4	TP
56	028_R_T_3	028_R_T_1	Correct	00:04.0	TP

57	029_L_T_3	024_R_T_2	Wrong	00:05.0	FP
58	029_R_T_3	029_R_T_1	Correct	00:04.4	TP
59	030_L_T_3	030_L_T_1	Correct	00:04.0	TP
60	030_R_T_3	030_R_T_1	Correct	00:04.2	TP
61	031_L_T_3	031_L_T_1	Correct	00:04.5	TP
62	031_R_T_3	031_R_T_1	Correct	00:04.2	TP
63	032_L_T_3	032_L_T_2	Correct	00:04.8	TP
64	032_R_T_3	032_R_T_2	Correct	00:04.8	TP
65	033_L_T_3	033_L_T_2	Correct	00:05.0	TP
66	033_R_T_3	033_R_T_1	Correct	00:05.0	TP
67	034_L_T_3	034_L_T_1	Correct	00:04.8	TP
68	034_R_T_3	034_R_T_2	Correct	00:04.8	TP
69	035_L_T_3	035_L_T_2	Correct	00:04.6	TP
70	035_R_T_3	035_R_T_1	Correct	00:04.9	TP
71	036_L_T_3	036_L_T_1	Correct	00:04.8	TP
72	036_R_T_3	036_R_T_1	Correct	00:04.8	TP
73	037_L_T_3	037_L_T_1	Correct	00:04.9	TP
74	037_R_R_3	037_R_T_2	Correct	00:04.8	TP
75	038_L_T_3	018_L_T_2	Wrong	00:05.0	FP
76	038_R_T_3	038_R_T_1	Correct	00:04.8	TP
77	039_L_T_3	039_L_T_2	Correct	00:05.1	TP
78	039_R_T_3	039_R_T_9	Correct	00:05.1	TP
79	040_L_T_3	040_L_T_2	Correct	00:05.0	TP
80	040_R_T_3	040_R_T_1	Correct	00:04.7	TP
81	041_L_T_3	041_L_T_1	Correct	00:05.1	TP
82	041_R_T_3	013_L_T_2	Wrong	00:04.7	FP
83	042_L_T_3	042_L_T_1	Correct	00:04.8	TP
84	042_R_T_3	042_R_T_2	Correct	00:04.6	TP
85	043_L_T_1	Not recognized	Correct	00:04.9	TN
86	043_L_T_2	Not recognized	Correct	00:04.8	TN
87	043_L_T_3	Not recognized	Correct	00:04.6	TN
88	043_R_T_1	Not recognized	Correct	00:04.6	TN

89	043_R_T_2	Not recognized	Correct	00:04.6	TN
90	043_R_T_3	Not recognized	Correct	00:04.8	TN
91	044_L_T_1	011_L_T_1	Wrong	00:04.6	FN
92	044_L_T_2	Not recognized	Correct	00:04.9	TN
93	044_L_T_3	Not recognized	Correct	00:04.9	TN
94	044_R_T_1	016_L_T_2	Wrong	00:04.8	FN
95	044_R_T_2	Not recognized	Correct	00:04.7	TN
96	044_R_T_3	Not recognized	Correct	00:04.7	TN

The system has a False Accept Rate of 0.83, False Reject Rate of 0.01 and accuracy of 87% with average execution time of 4.81 secs as shown in the Table 4.2.

$$\text{FAR} = \frac{10}{12} = 0.83$$

$$\text{FRR} = \frac{2}{168} = 0.01$$

$$\text{Accuracy} = \frac{74+10}{96}\ X\ 100\% = 87\%$$

$$\text{AET} = \frac{461.7}{96} = 4.81 secs$$

Table 4.2: System Evaluation Result

False Accept Rate	0.83
False Reject Rate	0.01
Accuracy	87%
Average Execution Time	4.81sec

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This project mainly comprised of development of attendance management system using fingerprint as the unique trait of identification. Fingerprint attendance management is very helpful in saving valuable time of students and teachers, paper and generating report at required time. The system showed the ability to store the necessary data for proper system implementation which include identifying students and generating attendance reports for a particular lesson. From the result gotten, the attendance system has an accuracy of 87%, with average execution time of 4.81 secs. This project has developed a software prototype of a fingerprint based attendance system.

5.2 Challenges

In the process of developing this project, some challenges were encountered, which include:

i. Difficulty in convincing students on how safe their fingerprint sample are, during and after completion of the project.

ii. Difficulty in making convinced students wait long enough to acquire the number of fingerprint samples needed for the project.

5.3 Recommendations

Although this project shows a reasonable level of accuracy, further improvement can be undertaken in the following areas:

i. Attempt to use better classifier other than Euclidean distance for the classification of fingerprint images so as to achieve a more accurate result.

ii. Attempt to use real - time images for verification and identification as against offline images used in this project.

iii. Development of hardware prototype which will function as a stand – alone system.

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