

**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI,
GHANA**

COLLEGE OF SCIENCE

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

**FINGERPRINTING AND CRIMINAL IDENTIFICATION – A CASE STUDY OF
ASHANTI REGIONAL CRIMINAL INVESTIGATION DEPARTMENT**

**A THESIS SUBMITTED TO THE DEPARTMENT OF BIOCHEMISTRY AND
BIOTECHNOLOGY, FACULTY OF BIOSCIENCE, COLLEGE OF SCIENCE
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF
MASTER OF SCIENCE IN FORENSIC SCIENCE**

BY

FRANK OSAE OTCHERE (BSc. Human Resource Management)

JUNE, 2019

DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor materials which to a substantial extent have been accepted for the award of any other degree or diploma at Kwame Nkrumah University of Science and Technology, Kumasi or any other educational institution, except where due acknowledgment is made in the thesis.

Frank Osae Otchere

(PG1142517)

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Signature

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Date

Certified by:

Dr. Caleb Kesse Frempong

(Supervisor)

.....

Signature

.....

Date

Prof. (Mrs.) Antonia Y. Tetteh (Head of Department)

Signature

Date

DEDICATION

I dedicate this thesis to the Almighty God, my wife, Mrs. Philomena Osae Otchere (Esq.), and my father, Mr. Emmanuel Osae Otchere.

ACKNOWLEDGEMENTS

Foremost, I am grateful to God for seeing me through my entire years of graduate school education. He has been the wind beneath my wings. His grace and mercy has brought me this far and I am grateful. My deepest appreciation goes to my supervisor, Dr. Caleb Firempong for his guidance and constructive criticisms that helped me stay focused from the beginning of this research work to the end. My sincere gratitude goes to Dr. Edward Appiah (Senior Lecturer, Department of Communication Design, KNUST) for his immense help and contributions. Moreover, I am grateful to Mr. Francis Mintah for his enormous contribution to this thesis. I want to thank the entire work force of the Ghana Police Service, especially Mr. David Asante Appeatu (IGP), COP Mr. Ken Yeboah (Director of Administration), COP Mrs. Maame Yaa Tiwaah Addo Danquah (Director General CID), ACP Mr. George Tweneboah (Deputy Director General CID), ACP Mr. Nuhu Jango (Divisional Commander, Ashanti Central), ACP Mr. Atiniak Peter Baba (Regional Crime – Ash), ACP Mr. I. K. Buah (Divisional Commander, Manhyia), C/SUPT. Mr. Emmanuel Ayeh Akunnor (Esq., Jupol/BA), SUPT. Mr. Emmanuel Lartey Lawson (Serious Crime Office, CID HQRS), SUPT. Mr. Kwabena Otuo Achemapong (Regional Crime Officer, Tamale), SUPT. Mrs. Mercy Agyapong (Director Forensic Crime laboratory, Accra), DSP. Mr. Charles Appiah (Crime Officer, Manhyia), ASP Mrs. Bernice Konadu Akyeamaah (MTTD Commander, KNUST), Mr. Richard Anatty (Cadet Officer, Ghana Police Academy) for their immense support and advice throughout my studies. Finally, my health felt appreciation goes to Very Rev. Major Noah Boahen (Chaplain - 4GMPC, Kumasi), Mrs. Doris Kokuma (Senior Lecturer, UCOMS), and Mrs. Paulina Oppong Boakye for their support. God bless you all.

ABSTRACT

Fingerprinting technique is a new age technology, specifically used for the identification of humans. The technology has been adopted by various institutions including the Ghana Police Service in order to link suspects to crimes. However, records on fingerprinting in Ghana's security services have not been the best for successful criminal identification. Therefore, the present study was to evaluate the level of efficiency of fingerprint capturing and matching techniques adopted by the Ghana Police Service. A cross sectional design was used where descriptive method was adopted. A sample size of 210 criminal investigators within the Ashanti Region of the Ghana Police Service was selected via simple randomization. The investigators were taken through structured questionnaires which focused on the use, impact and challenges associated with fingerprint technique application in the Ghana Police Service. Criminal records at all the stations within the Ashanti Regional Command for 2018 were also analyzed to ascertain the cases that were linked to the technique. The results showed that the criminal investigators with the technological know-how on the application were more than 75% at all the divisions; however, only few successful cases (at most 0.71%) were linked to the technique. The investigators also had a lukewarm attitude towards the use of the technique even though they highly acknowledged the positive impact (approximately 4.00 ± 1.20 , meaning highly agreed). Some of the significant impacts provided by the respondents include enhancement of productivity, speeding of criminal proceedings and reduction in ambiguity during criminal investigations. The major challenge to the application of fingerprint technique at the Ashanti Regional Command was the inadequate availability of resources (approximately 4.00 ± 1.52). The other mild issues relating to the application included improper fingerprint capturing and matching equipment, poor infrastructure for the technique and less training for personnel. All these findings clearly revealed the need to significantly improve on the application of fingerprint capturing and matching technique at the Ashanti Regional Police Command to facilitate criminal identification and prosecution in the region.



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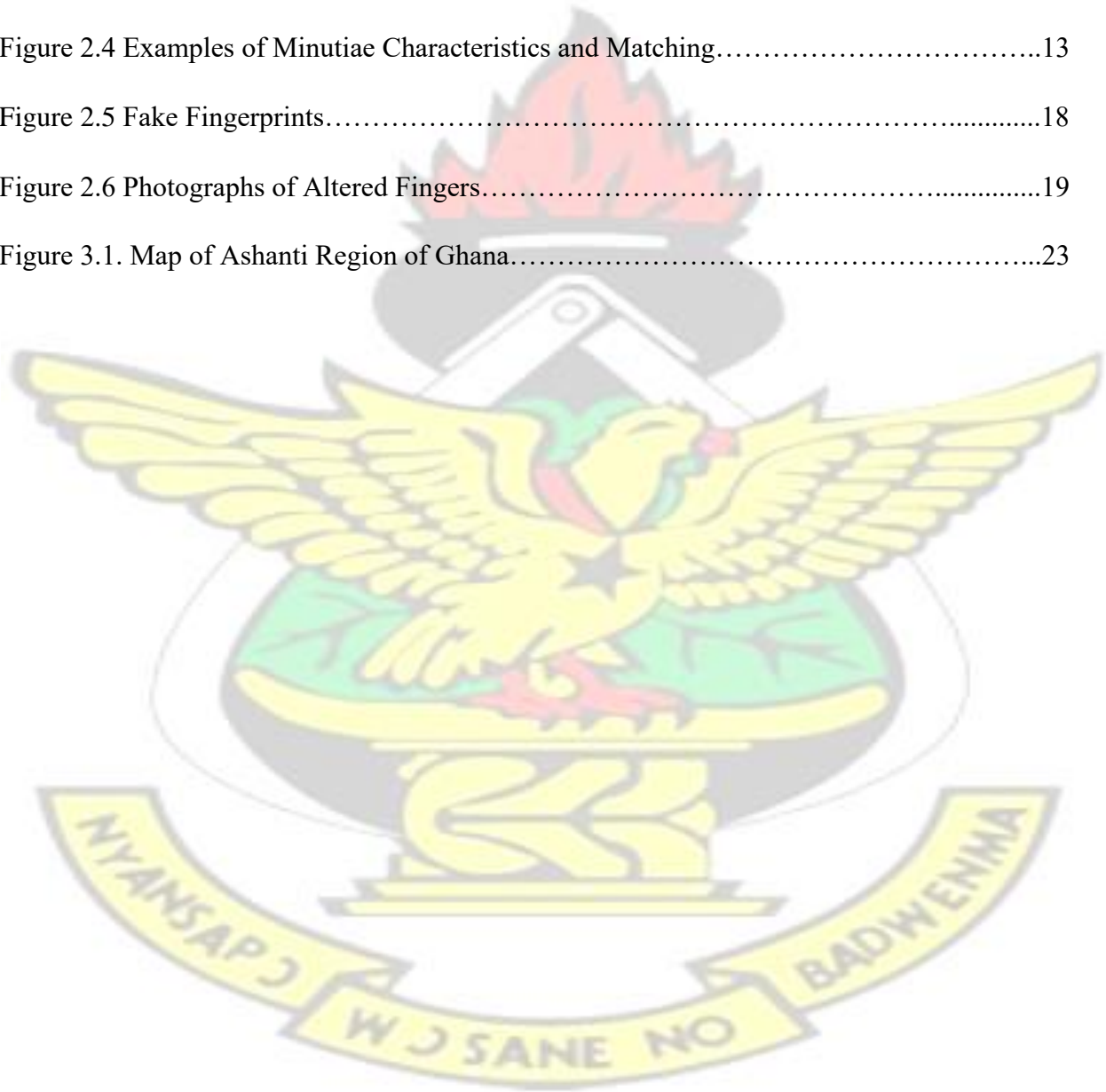
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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Crime has existed for several centuries within societies. In recent times, criminal cases have been on the rise and gradually becoming a common entity among different societies (United Nations Office of Drug and Crime UNODC, 2016). Although Ghana is considered a peaceful nation, its crime rate has been on the rise (Otchere, 2007). The criminal cases associated with the country usually include armed robbery, drug dealing, money laundering, theft, and rape (Ghana Prison Administration, 2018). However, according to the Criminal Code of Ghana, Act, 2960, corporal punishment is not allowed in criminal cases but various terms of imprisonment have been prescribed for both first and second-degree felonies. According to the Institute of Criminal Policy Research (2018), the world prison brief of Ghana estimated that the prison population trend increased by 7% from 2016 to 2018. Fafa (2010), therefore, asserted that if the crime rate is not dealt with in a pragmatic approach, the country will be plunged into much chaos, fear and panic amongst citizens. Ghana Police Service has instituted several platforms and methods to curb the issues of crime within the country.

Personality identification has, therefore, become a prominent task for most countries across the globe in the issues of crimes (Kanbar, 2016). Several studies have identified effective, safe, and fast forensic methods for personality identification of criminals. The most commonly used forensic methods include dental, fingerprint, lip print and DNA comparisons. Irrespective of the recent developments in the application of DNA to detect crimes, fingerprinting still remains as an essential component in criminal investigations (Bond, 2008). Fingerprinting is easier and faster to use. Moreover, fingerprinting offers a straightforward, cost-efficient method that could easily be

useful to large populations and seemed to warrant broadly generalizable results (Mnookin *et al.*, 2011). Fingerprints are considered not to lie since no two individuals have the same fingerprints considering them as self-signatures (Galton, 1982; Cole, 2001; Lynch *et al.*, 2010). The unique characteristics of fingerprints and its associated techniques have rendered them an indispensable source for scientific study (Thompson and Sue, 2007). Therefore, in recent times, fingerprinting has become extremely ubiquitous as both practice and idea in contemporary studies (Jeddy *et al.*, 2017; Jeffreys, 2004).

In the law courts, forensic evidence is mostly considered as valid and reliable (Loftus and Cole, 2004; Saks and Koehler, 2005; Edwards, 2009; Spinney, 2010). However, the validity and interpretation of forensic studies cannot exist alone in scientific studies (National Research Council, 2009). Therefore, the establishment of evidence-based standards for instance fingerprinting, is essential in the entire process. Hence, this study seeks to examine fingerprinting capturing and matching techniques as applied in the Ashanti Regional Police Service.

1.2 Problem Statement

Criminal investigations have been a prime entity in the Ghana Police Service. The Ghana Police Service is noted for prosecuting suspected criminals at courts for appropriate judgments. However, in Ghana, there are some situations where the true culprits of the crime are not apprehended due to poor criminal identification as a result of inadequate use of forensic techniques. According to Lynch *et al.* (2010), fingerprints provide an authentic data since no two individuals have the same fingerprints which single out these prints as self-signatures.

Several specialized areas such as medicine and aviation have received enough training on fingerprinting identification (Mnookin *et al.*, 2011). However, there are woefully inadequate

studies on fingerprinting identification by the security services in Ghana (Awuah *et al.*, 2017). Moreover, progressive advances in the fingerprint development process have been made, but the critical human decision-making element has been neglected (Thompson & McCarthy, 2013). Traditional techniques for human-identity verification has suffered from many security vulnerabilities such as masquerading identity and mobility issues (include lost, forgery and misplacement items). Therefore, it has become necessary to identify a much better and rapid approach in tracing individuals with criminal records. The identification of fingerprint evidence is often considered as an important key in solving a crime (Trozzi *et al.*, 2001). Even though the Criminal Investigation department of the Ghana Police Service is well versed in the use of fingerprint in their investigative activities, there is limited data on the use of fingerprint matching as an effective investigative tool in Ghana (Fafa, 2010). Records on fingerprinting matching among security services in Ghana have also not been the best for successful criminal identification.

1.3 Research Objectives

The aim of the study is to evaluate the efficiency of fingerprint capturing and matching techniques adopted in the Ashanti Regional Ghana Police Service for criminal identification.

The specific objectives:

- i. To establish the extent of the use of fingerprint capturing and matching techniques in the identification of criminals in the Ashanti Regional Ghana Police Service.
- ii. To determine the impact of fingerprint capturing and matching techniques on criminal investigations in the Ashanti Regional Ghana Police Service.
- iii. To determine challenges associated with the fingerprint capturing and matching techniques in the Ashanti Regional Ghana Police Service.

- iv. To evaluate criminal records to ascertain the number of cases linked to fingerprint capturing and matching techniques in the Ashanti Regional Ghana Police Service.

1.4 Justification

The outcome of the present study will provide credible information on the state of fingerprint application in the identification of criminals in the Ashanti Region of Ghana. The results will also enable the Ashanti Regional Police Command and by extension the Ghana Police Administration to appreciate the present impact of fingerprint identification in effective criminal prosecution so that they can put the necessary measures in place to strengthen its use in criminal investigations across the country. The data will further highly encourage the use of the application to improve the investigative and prosecutorial activities of the Ghana Police Service, especially in Ashanti Region.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter dealt with the review of related but extant studies published by accredited scholars and researchers. The focus of this section was to aid readers and other scholars to identify the variations and similarities that exist between this current study and previous related studies. Additionally, this chapter creates a justification for the essence for prospective researches in this field.

2.2 Fingerprint Identification

The published work of Galton (1982) gave exploratory findings of fingerprinting and its associated heredity. According to Norris and Charis (1990), these ancient works necessitated the introduction of fingerprints in anthropological studies. Fingerprinting is among the long existing techniques applied in forensic studies which are primarily used for the unique identification and linking of an individual for law enforcement resolutions (James and Jon, 2003; Singh *et al.*, 2018). Evidence from signatures and photographs have been used but failed due to the nonlinkage of fingerprinting techniques to several cases of accident, murder, or suicide. (Galton, 1982; Eboh, 2013).

Fingerprint Identification can be described as the means of using impressions on fingertips to associate to an individual. According to Korzeniowski (2007), no two individuals possess the exact ridge pattern arrangement on their fingertips and the patterns forever remains unchanged on an individual. Therefore, fingerprint can be regarded as a means of rendering infallible personal identification to individuals. However, the use of traditional methods such as powders, liquids, and vapors can destruct the patterns making identification a tedious one. Since the conception of fingerprint technology, there has been several improvements and developments (Godiglo, 2008). Trends in biometric imaging technology have reduced errors associated to the technology to about

8% (Mucklestone and Louie, 2006). Historically, an estimated 6000 years old earthenware vessel which was exposed in northwest China and found to be having undoubtedly noticeable abrasion ridge impression and is considered to be the oldest friction ridge skin impression of a fingerprint found to date. However, the contentions still exist concerning whether the emergence of such imprints was by mere accidents or for decorative purposes. (The Fingerprint Sourcebook, 2011).

2.3 Applications of Fingerprinting

Human recognition and identification with respect to fingerprint is widely adopted for various applications including law enforcement issues, international border control issues, and personal laptop access issues. On a global scale, most law enforcement agencies habitually use the fingerprints of criminals to apprehend them and track their criminal history as well. The primary application of fingerprint is for criminal identification and apprehension (Michielsen, 2005). The fingerprints are processed through the Integrated Automated Fingerprint Identification System (IAFIS) where responses are sent within two hours to the contributing agency for electronic criminal fingerprint submissions and within 24- hour for electronic civil fingerprint submission (Hooshang, 2000). Therefore, with respect to fingerprint processing, individual identification has been reduced from months to hours. According to Fisher (2004), fingerprint identification fulfills several roles in criminal investigations including: proving or establishing the commitment of a crime, corresponding the suspect with the victim or the crime scene, establishing the identity of individuals connected to a crime, vindicating the innocent, validating the testimonies of victims and suspect to a crime, assisting in the fact finding mission during investigations.

Several studies have established the impact of forensic evidence such as fingerprint identification on the arrest and prosecution of suspects (Block, 1969; Evans, 1996; Ramsland, 2001; Ragle,

2002; Lee, 2002; Corwin, 2003; Lee & Tirnady, 2003; Platt, 2003; Ramsland, 2004; Snow, 2005). Findings of these studies have been very essential to the solution of criminal issues using forensic evidences. In recent times, fingerprint technology has seen many applications in accessing personal computers, phones, restricted areas, and authorizing transactions. Fingerprints exist in three major classifications of impressions which include latent, known, and plastic impressions (Dror *et al.*, 2006). Latent impressions are usually two-dimensional reproduction of ridges which are usually placed by chance with different levels of quality. These impressions are mostly made visible through then adoption of forensic technologies including chemical techniques, alternate light sources, and fingerprint powders (Vokey *et al.*, 2009). However, a known impression is formed due to the intentional reproduction of ridges which can be identified with the use of ink, chemical methods, and computer-based live scan. Plastic impressions are usually left on malleable surface such as was through the retaining of the arrangement of the ridges on the finger (Snady, 2005).

2.4 Types of Fingerprint Patterns

According to Adebisi (2009), the application of fingerprints has resulted as a remedy for identification during forensic investigations. However, in fingerprint matching analysis, the comparison of the patterns of fingerprints is essential. These patterns are visible due to the accumulation of unique ridge and minutiae characteristics identified (Jain *et al.*, 1999). Scientists started describing the uniqueness and permanence of fingerprints since the 19th century. They classified fingerprint patterns with much consideration to the arches (such as plain arch and tented arch), loops (such as ulnar loop and radial loop), and whorls (such as central pocket whorl, double loop whorl, accidental loop whorl, and accidental whorl) (Langerberg, 2005). A loop pattern occurs when the ridge enters and exit from the same point of the finger and forms a curve, whereas the arch pattern is formed when the center forms an arc with the ridges entering and exiting from

different points (Adamu, 2012). The whorl pattern is formed when a circular ridge is formed at the center of the finger (Adamu, 2012). Figure 2.1 shows the patterns and minutiae of fingerprints. The patterns of fingerprints are likely to differ among different populations. According to Newman (2010), about 60-65% of population has loops, 30-35% of the population have whorls and 5-10% of population have arches. In a related study conducted among the Hausa ethnic group in Nigeria by Danborno and Idris (2007), they made evident that 29.74% of the population had whorl patterns, 63.59% had loop patterns, and 6.62% had arch patterns. They found similar distribution of patterns among the Yoruba population where 26.03% had whorl patterns, 63.45% had loop patterns, and 10.5% had arch patterns. These findings were similar to a study conducted among the Asante populations in Ghana by Awuah *et al.* (2017), where 22.55% had whorls, 68.45% had loop, and 9.0% had arch patterns.



Figure 2.1. (A) Patterns of fingerprints (B) Minutiae of Fingerprint

The unique fingerprint pattern initiates during foetal development within the first sixth month of gestation. The exclusivity of friction ridge skin tumbles beneath the broader perspective of biological exceptionality and no similarity exist between the fingerprints of two different individuals (Diego-Alvarado and Ramírez, 2011). Within the 6th and 7th weeks of gestation, the paddle like hand of the foetus begins to develop fingers (Daluz, 2014). Volar pads starts appearing

on the palm (inter-digital pads first, followed by thenar and hypothenar pads) around 7th to 8th weeks of gestation and the major development of friction ridge skin occurs around 11th and 20th weeks of gestation (Christophe *et al.*, 2004). The morphology of volar pads results into fingerprint patterns which are unique in terms of types and location of microscopic details (Daluz, 2014). Sexual dimorphism in dermatoglyphic patterns is connected to heritability (Arrieta *et al.*, 1991; Awuah *et al.*, 2017). A statistically significant variation in sexual dimorphism enriches the genuineness and legitimacy of fingerprints in the determination of crimes and identification of the source of unknown prints (Deopa *et al.*, 2014).

The similarity or dissimilarity within a pair of fingerprints solely depends on the amount of information in each and the examiner's working experience with fingerprints. However, no collective definition or measure of similarity for the comparison of prints exists, but several attempts have been made to construct an objective dimension of similarity. For instance, Vokey *et al.* (2009) changed a set of fingerprint images into their raw pixel values (that is the brightness values in each fingerprint image) and anticipated each print into the multidimensional planetary of all the prints in a set to return a vector, where similarity existing between two prints is given by the cosine of the angle between their vectors. A cosine value close to 1 indicates that the prints are virtually identical; whereas cosines close to zero indicate that the prints are highly dissimilar. This technique, therefore, delivers an impartial extent of comparison since it adopts only the raw pixel values in the images and so necessitates no human input.

2.5 Methods of Fingerprint Identification

In the context of automatic fingerprint identification system, two major steps which include fingerprint image enhancement and minutiae matching play essential roles. The impressions carved by the tiny ridge patterns on the fingertips are usually used as the method of fingerprint identification. Generally, the minutiae in the form of ridge endings and bifurcation are used to represent a fingerprint and minutiae matching are conducted to match the fingerprints (Dalrymple *et al.*, 2002). This then comprise of both storage and matching of fingerprints. Prior to the fingerprint matching process at a crime scene, an image enhancement is carried out using Fast Fourier Transform method to remove regular patterns from the background of the image (Dalrymple, 2004). Figure 2.2 shows the use of Fast Fourier Transform method to remove the background of a fingerprint image. This makes it easier to capture the patterns of the fingerprint. The template storing step involves the acquisition and enhancement of fingerprint using various algorithms to store fingerprint in a database system (Dalrymple *et al.*, 2002). Afterwards, when a new fingerprint is captured, the fingerprint is fed into a matching model and matched against the template in the database (Afsar *et al.*, 2004). Figure 2.3 shows a schematic flowchart of fingerprint identification system.

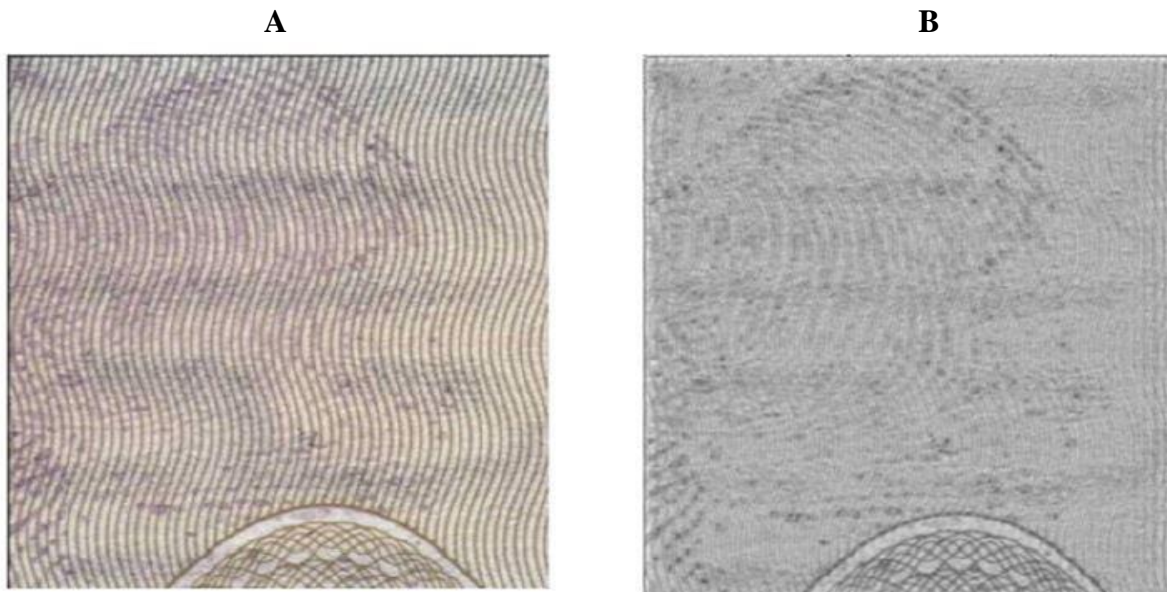
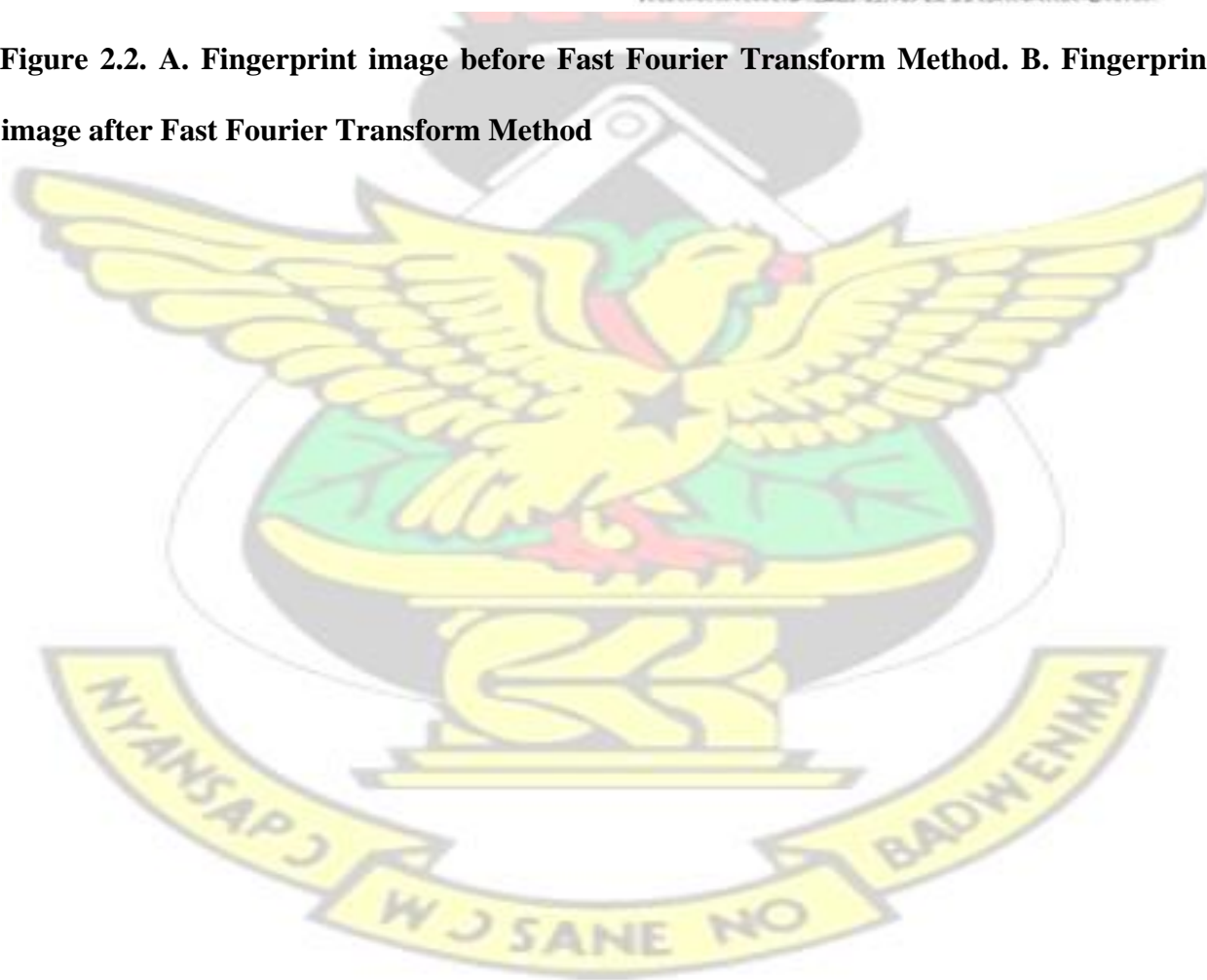


Figure 2.2. A. Fingerprint image before Fast Fourier Transform Method. B. Fingerprint image after Fast Fourier Transform Method



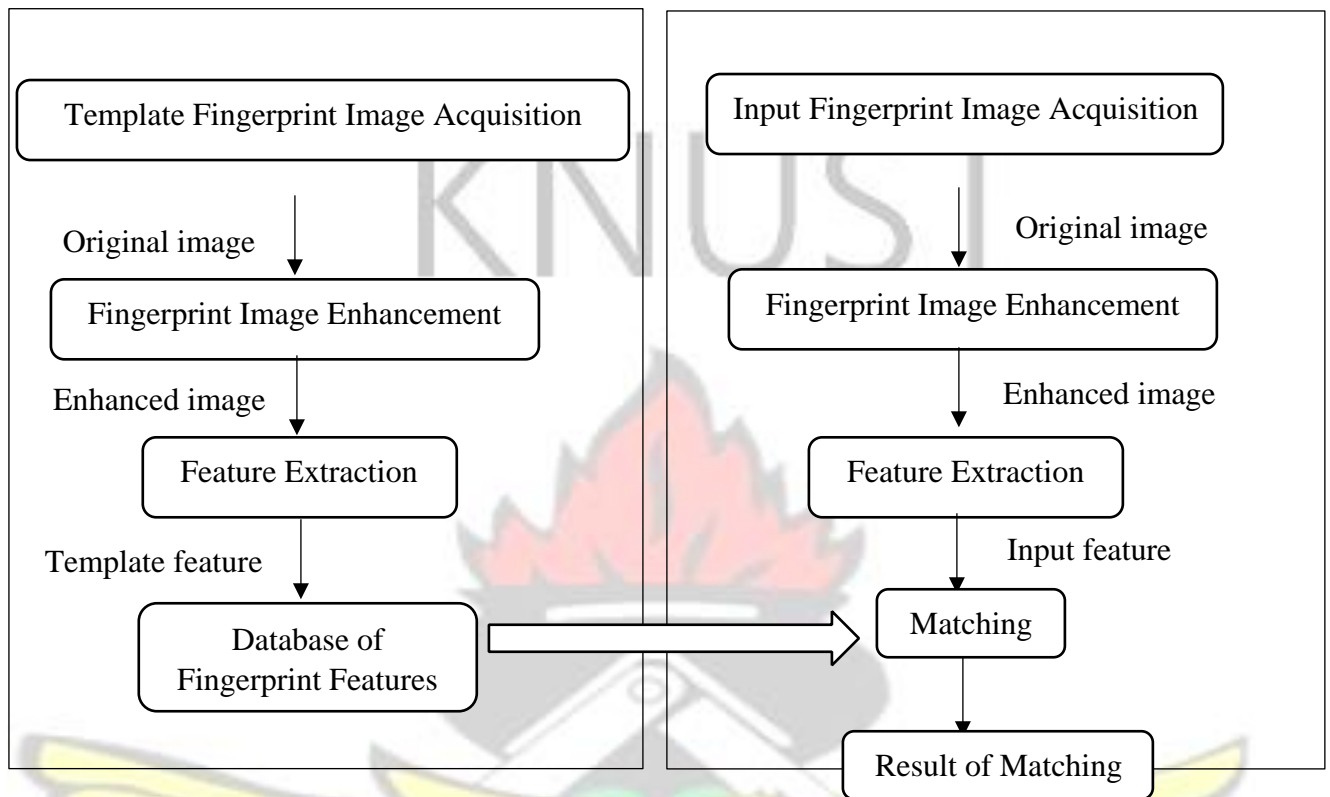


Figure 2.3. A schematic flowchart of fingerprint identification system

With the use of a minutiae-based technique, identified minutiae points are mapped onto their virtual placement on the finger. Interestingly, this approach is characterised with major difficulties. For instance, the accurate extraction of minutiae points are difficult especially when the quality of fingerprint is low (Takeda and Uchida, 2011). According to Kanbar (2016), the quality of fingerprints is affected by sensor noise, skin conditions, and varying contact with sensor surface. Moreover, this method does not consider the total patterns of ridges and furrows on the image. For an effective fingerprint matching process, most fingerprint images must be enhanced at the recognition step since most fingerprint images are characterised with poor quality (Dalrymple and Keithwoods, 2002). Figure 2.4 shows examples of minutiae and matching between two fingerprints.

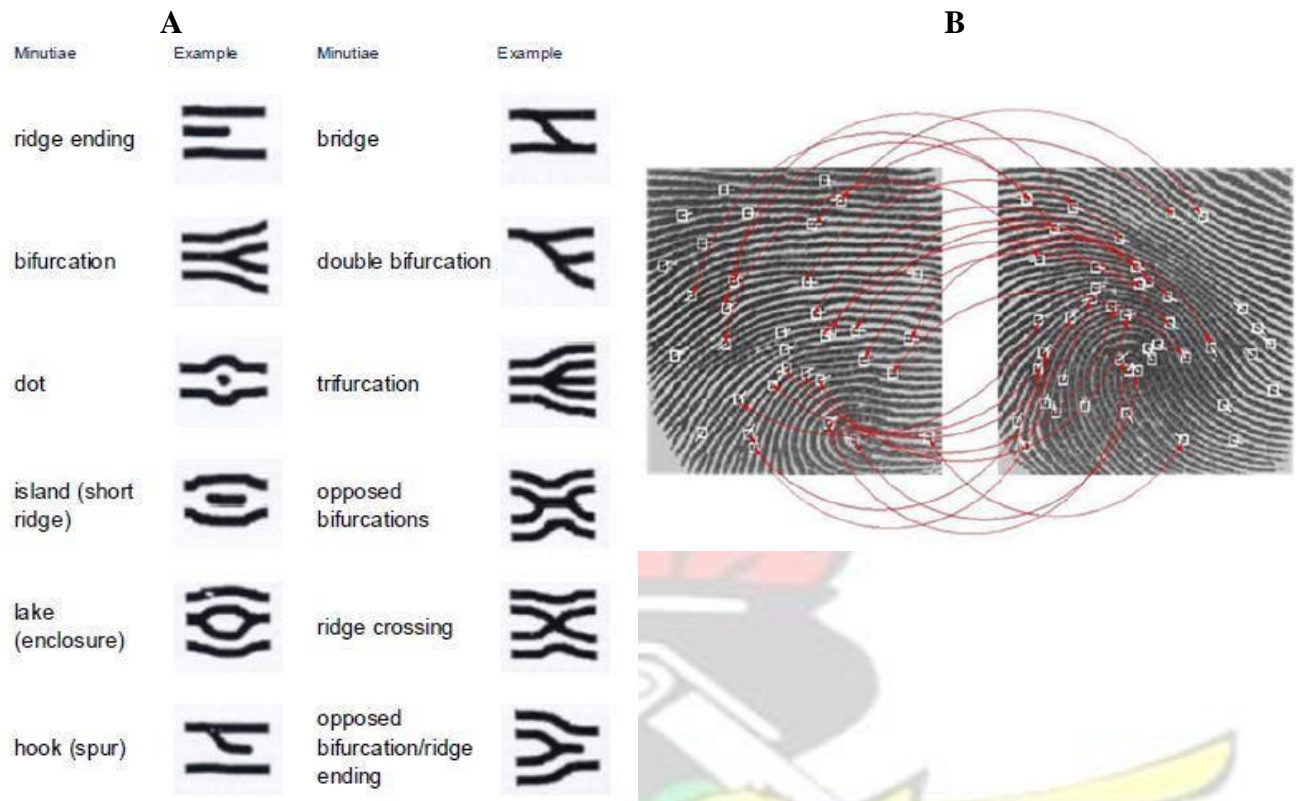


Figure 2.4. A. Examples of Minutiae Characteristics B. Minutiae Matching

Numerous typologies have been developed with respect to forensic evidence at crime scenes and other criminal evidences (Ragle, 2002; Fisher, 2004; Gardner, 2004; Lee, Palmbach, & Miller, 2004).

2.6 Crimes in Ghana

Ghana has been globally considered as a peaceful country within the Africa continent. However, the country is characterized by heightened forms of crimes which is gradually eroding the country's reputation. The word crime originated from the Latin word *cernō*, meaning "charge" or "cry of distress". However, the Ancient Greek captured crime as *krima*, which meant an intellectual offense committed against the society and not the individual himself. Therefore, crime can be defined in different contexts depending on the society and time (Agyemang, 2012).

According to the Criminal Code of Ghana (Act, 2960), crime occurs when there is both the intention to commit an act and the commitment of the act. In another sense, Fafa (2010) considered crime as one's deviation from rules and regulations governing a particular institution or society. For the purpose of this study, crime is defined as the result of one's non-compliance to rules and regulations governing a society or institution. Varying forms of crime occur within societies and institutions, Criminal Code of Ghana (Act, 2960) and Levitt (1996) categorized the crimes into robbery, burglary, motor vehicle theft, larceny, forcible rape, murder, aggravated assault. These offenses have huge detrimental effects or impacts on the society as compared to the individual committing the said act of offense. Some examples of the negative impacts include: security threat, loss of properties and lives, fear and panic, and budget constraints.

Cybercrime is quite a new phenomenon in Ghana (Warner, 2011). In 2010, the flawless and sparkling image of Ghana with respect to cybercrime was tarnished. Together with Nigeria and Cameroon, Ghana has achieved the unsavory distinction as one of the top ten cybercrime generating states across the world (Warner, 2011). In addition to its disconcerting state, a preceding report also discovered that Ghana was the second most habitually blocked location by the United States of America in the West African Region (Kwablah, 2009). This then necessitates an emergence of inquiry into the risen cybercrime issues in one of the super power country in the Sub-Saharan Africa. Increased accessibility to internet and increasing numbers of systems worldwide, have capacitated criminals to use unauthorized access to weakly protected systems for sabotage, political action and financial gain (Kabay, 2008). During the 1990s, financial crimes using penetration and sabotage of computer systems increased (Rollins & Wyler, 2010). The types of malware shifted during the 1990s, taking advantage of new vulnerabilities. Illegitimate applications of e-mail grew rapidly from the mid-1990s onward,

generating torrents of unsolicited commercial and fraudulent e-mails (Rollins and Wyler, 2010). According to Aidoo *et al.* (2012), ICT crime denotes the use of computers by individuals in one of three ways; which are: computer as a target of offence, computer as a tool of offence, and computers as incidental objects to the offence. They further contended that management of most organisations do not realize the value of prevention in the area of computer security, but wait in ignorance until an incident occurs or is detected.

2.7 Adoption of Fingerprint Identification and Matching Technique in Ghana Police Service

The adoption of biometric technologies such as fingerprint identification and matching has not been a new idea since dactyloscopy remains an essential component in law enforcement (Hoover, 2008). The Ghana Police Service have been operating with the manual fingerprint identification and matching technique since 1950s to investigate criminal cases (Ghana Police Report, 2017). However, due to the shortfalls accompanying the manual fingerprinting process, the automated fingerprint identification system has been introduced into the Ghana Police Service within the past five years. For instance, the manual fingerprint identification system took the Ghana Police Service approximately more than 20 working days to compare and classify fingerprint; a process which could be finalized within 7 days with the use of biometric system. Interestingly, the high increasing numbers of criminal cases in the country necessitates a much faster approach in criminal investigations in Ghana. Globally, the use of fingerprint technologies have yielded positive impacts on law enforcement institutions (Zalman, 2011). Nevertheless, an assessment of the flaws of the fingerprint technology is dependent on the technological interventions of said police units. Aside, the superior nature of automated fingerprint systems over manual fingerprint systems, the manual fingerprint system cannot be discarded outright since technologies are fallible, and in cases of malfunctioning, investigators can resort to the manual system (Moses, 2011).

The application of fingerprint and matching techniques has extended beyond the law enforcement domain of the country (Jamieson *et al.*, 2005). Therefore, it is asserted that the technology is prone to serious difficulties and challenges in the long-term since there is a massive rush to capitalize on their gains. Contrarily, Rejman-Greene (2001) argues that the adoption of fingerprint and matching techniques can be used to yield their optimum results. The implementation of the automated fingerprint and matching technique in the Ghana Police Service has been scheduled to undergo 7 phases to render it successful to the institution. The following are the phases of implementation:

- Phase 1: Preparation, repairing, and bar coding, and capturing of alphanumeric data of fingerprints from national biometric cards.
- Phase 2: Customization and integration of standard software for the automated fingerprint capturing and matching system in the Ghana Police Service.
- Phase 3: Conversion of fingerprint card images into electronic layout.
- Phase 4: Loading of fingerprint images onto the database of the automated fingerprint software.
- Phase 5: Installation and implementation of hardware and software containing database in secured offices of the Ghana Police Service.
- Phase 6: Training of personnel to handle and operate the system.
- Phase 7: Implementation of the system across the piloted workstations to check efficiency of the system and fix the discrepancies. Mass implementation of the system across the entire country.

2.8 Effects of Fingerprinting Identification on Criminal Investigations

Irrespective of the superior and special capabilities of experts in fingerprint, there is the tendency of their decisions being influenced by unnecessary and inappropriate information (Busey and Dror, 2010; Dror, 2011). Therefore, several mitigation rules toward contextual bias have been outlined and suggested by various researchers (Dror, 2012). In the midst of this contribution, however, relatively insufficient studies on human fingerprint identification have been carried out by professionals and researchers alike. Much of the prevailing studies on the cognitive factors associated with fingerprint judgment has examined the effect of contextual information on the performance of experts in fingerprinting recognition and identification. Dror *et al.* (2006), used a highly publicized case of exposed fingerprint error to ascertain the influence of bias information on the judgment of fingerprinting experts. Mnookin *et al.* (2011), contends and establishes a genuine role for experience-based claims of knowledge, but also that pattern identification disciplines must develop a scientific foundation, through research focused on the standards of pragmatism and cynicism.

2.9 Challenges Associated with the Fingerprint Capturing and Matching Techniques

The widespread deployment of Automated Fingerprint Information System within the areas such as law institutions, immigration centres, and gaining of access into well secured facilities has impelled some persons to involve in exciting measures for the drive of circumventing the system: (i) fingerprint hoaxing and (ii) fingerprint modification. Fingerprint hoaxing involves the usage of misleading fingers made of latex or glue – is a well-known technique in adopting other people's identity. Figure 2.5 clearly demonstrates instances of misleading fingerprints where Figure 2.5(a) displays a sticky fingerprint from a decay made by requiring a press down of the finger on the relaxed plastic and coagulating resources such as rubber and silicone in the mold. Figure 2.5(b)

displays a dummy finger made of latex with comprehensive resistance pattern on the fingertip. In order to detect attacks based on fake fingers, widespread studies have been carried out on the biometric literature to evaluate the sensitivity of a finger that have ensued in: (i) software solutions and (ii) hardware solutions. Software solutions make use of the conservative fingerprint detecting device, nonetheless adopt a series of image edges of the fingerprint to detect perspiration array (Parthasaradhi *et al.*, 2005) or skin alteration (Antonelli *et al.*, 2006) of the finger. Contrarily, hardware solutions encompass extra sensing strategies to ascertain electrical resistance (Setlak, 1999) or spectral features (Nixon and Rowe, 2005) of the finger.

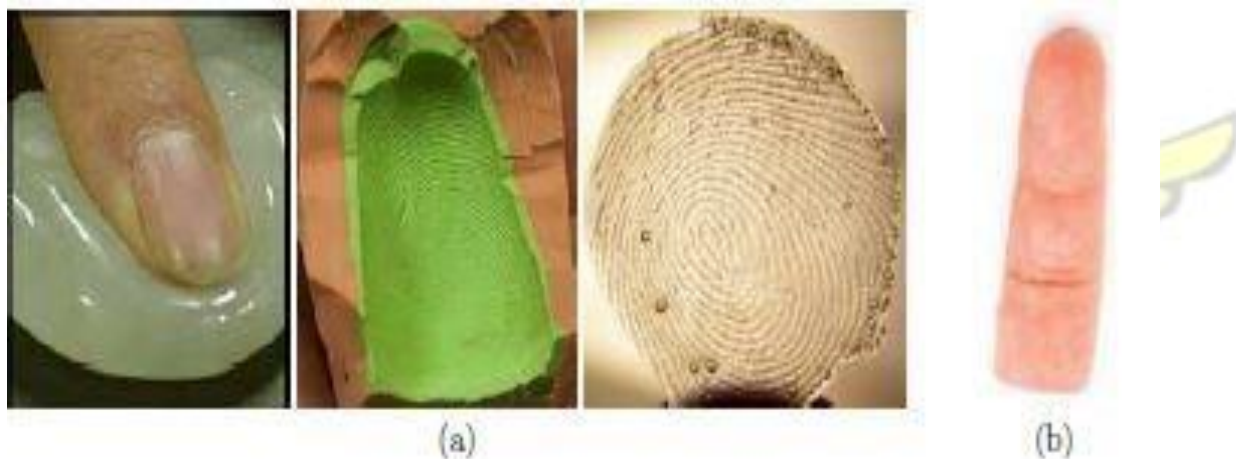


Figure 2.5. Fake fingerprints. (a) Sticky fingerprint: (left) pressing a finger on the relaxed plastic, (Center) the mold created from a finger, (Right) a sticky fingerprint from the mold, and (b) replica finger

(Source: Matsumoto *et al.*, 2002).

Distinct from sham fingers, fingerprints which are altered are actual fingers having ridge structure has been strictly altered by burning, cutting, abrading on the fingertips (Figure 2.6). The aim of fingerprint alteration is to obscure an individual's identity so as to avoid the Automated Fingerprint Information System. The challenge associated with altered fingerprints has previously not been considered and no stated techniques to recognize them exist. Though several algorithms and

approaches to evaluate the image quality of the fingerprint and to identify bogus fingerprints have been suggested, not any of them can be efficiently utilized to identify reformed fingerprints with recourse to the reason below: (i) Not all the reformed fingerprints are poor in quality and (ii) the reformed fingerprints are certainly from conscious fingers, so the detectors of bogus fingerprint which fundamentally ascertain the characteristics of conscious fingers is not possible. Therefore, in handling such problem of attacks on the system by fingerprint complication, an investigation into detecting altered fingerprints, analyzing altered fingerprints, and matching altered fingerprints to their pre-altered mates should be carried out.



Figure 2.6. Photographs of altered fingerprints. (a) Transplanted friction ridge skin from sole of the feet, (b) fingers that have been bitten, (c) fingers burnt by acid, and (d) stitched fingers

(Source: Hall, 2007; Singh, 2008).

2.9 Trends in Forensic Investigations for Crimes

Aside the use of fingerprinting as an approach in forensic investigations to link suspects to crimes, several approaches and trends have also emerged with ultimate significance to the investigation of crimes. Such trends include Forensic DNA Phenotyping, latent lip prints, and seminal fluid analysis. Forensic DNA Phenotyping is an approach in forensic science which involves the use of

Short Tandem Repeat (STR) to predict and link unknown sample or biological material at a crime scene to a suspect (Kayser, 2015). This method has been regarded as a golden standard in forensic studies (Santos *et al.*, 2013). However, this method is limited by the fact that there is the likelihood of failure in the analysis of linking crimes to suspects who do not have STR in the archives of the investigators. Therefore, for an effective forensic DNA phenotyping, forensic DNA databases are essential (Santos *et al.*, 2013). In cases, where there is absolute no data profile of suspected criminals, investigators usually invite for saliva sample from suspects for STR profiling. Interestingly, true perpetrators of the crime will voluntarily provide their samples and might raise suspicion and direct investigators to the crime leads on the actual perpetrators of the crime.

Lip prints are regarded as usual grooves and wrinkles existing in the transitional zone of the lips of humans, within the innermost outer skin and labial mucosa, inspection of which is regarded as Cheiloscopy. Patterns associated with lip groove infrequently alters, resisting several types of extraneous factors comprising pressure and exposure to hot or cold stimuli, and physical injury.

Its perpetuity permits it to be a consistent apparatus in the field investigations of forensic.

Particularly when associated with existing indication, it significantly enhances the accomplishment of crime solving enigmatic (Venkatesh and David, 2011). According to Neville *et al.* (2002) and Sivapathasundharam *et al.* (2001), no two individuals can possess the same lip prints except with the cases of a monozygotic twins. Moreover, lip grooves are permanent and unchangeable (Caldas *et al.*, 2007). The greasy and humid discharges from sebaceous and salivary glands situated at the vermilion boundary and succeeding moisturization from the tongue permits the development of a latent lip print on every occasion there is contact with lips leaving behind a significant form of transfer indication (Ahmed *et al.*, 2017). A lip print at the scene of crime can provide a clue for various questions as the type of the crime, the count of the people involved, occupational traits,

cosmetics used, sexes of suspects, habits, and the pathological changes of lips themselves (Alzapur *et al.*, 2017).

Protein components of semen are used in the screening of evidence to indicate or confirm that seminal fluid is present (Cotton and Fisher, 2015). Successful application of this procedure avoids having DNA from two individuals (assuming one female and one male source) in a single DNA extract and usually results in isolation of E cell DNA (from a victim) as a single source extract and sperm cell DNA in a second and separate extract. This approach is very useful in linking an individual to rape case.

The logo of Kwame Nkrumah University of Science and Technology (KNUST) is centered in the background. It features a yellow eagle with spread wings perched on a shield. Above the eagle is a torch with a red flame. The shield has a green base and a yellow top section. A banner at the bottom of the shield contains the text 'NYANSIN JO JO SANE NO SI BAWENMA' in yellow. The word 'KNUST' is written in large, light grey letters at the top of the page.

CHAPTER THREE

SUBJECTS AND METHOD

3.1 Introduction

The chapter seeks to provide the research method used for data collection and analysis. Moreover, the limitations associated with the study were also captured in this section.

3.2 Profile of the Study Area

The Ashanti Region is centrally situated in the geographical distribution of Ghana. The distinct central position renders it reachable by various places of the country. It is the second densely populated region in the country and its administrative capital is Kumasi. The metropolis is a fast emerging region with a population size of more than three million inhabitants and a 5.4% annual

growth rate (Ghana Statistical Report, 2017). The region has about 42 metropolitan, municipal and district assemblies. Due to the densely populated region, the Ghana police service has a formidable strong force there in order to maintain law and order in the region. The region is characterized by fourteen (14) divisions with 42 districts of the Ghana Police Service.

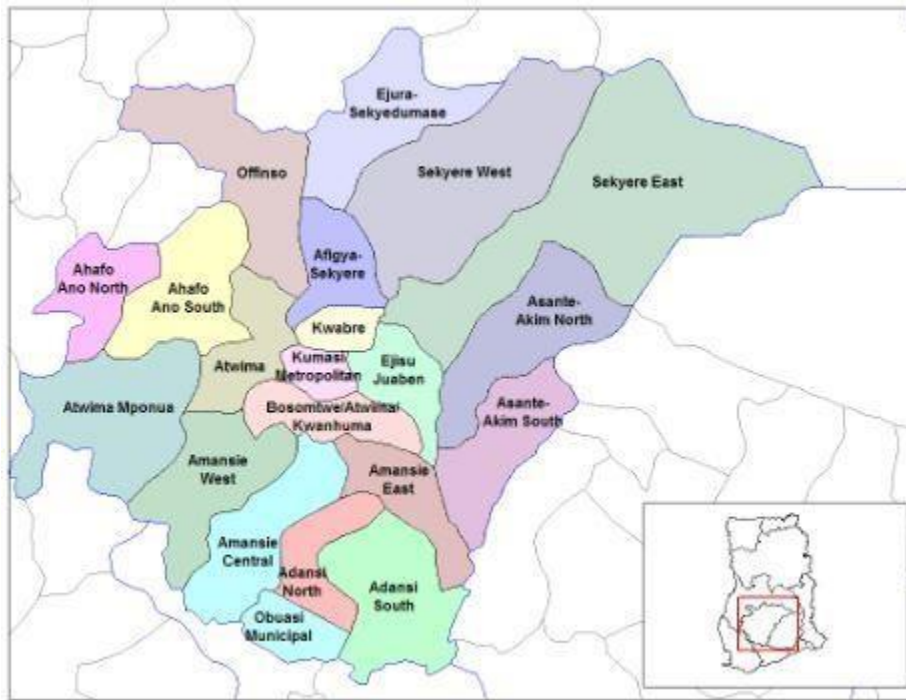


Figure 3.1. Map of Ashanti Region of Ghana

3.3 Research Design

A cross sectional research design and descriptive research method were used in the present study. Thus, a case study approach was adopted because the research was undertaken to observe an area with limited information on the problem under investigation. Nevertheless, this design was flexible throughout the entire research and usually done in an unstructured approach with an in-depth analysis. Since this study focuses on the evaluation of the efficiency of fingerprint capturing and matching techniques adopted in the Ghana Police Service, the suitable approach and design which was selected for this study was a quantitative approach.

3.4 Data Collection

Data collection is considered as the means of gathering and quantifying information on variables of interest in a conventional and systematic fashion that aids one to respond to the outlined research questions and evaluate possible outcomes. Several ways of collecting data exist but the researcher can use the self-administered open and close-ended questionnaire in which respondents can be allowed to respond to the questionnaire administered. The questionnaire focused on addressing the issues based on the objectives of the study. With respect to the close-ended questions, aside the bio-data information on the questionnaire, the remaining information were measured using a 5-point Likert scale. The open-ended provided respondents the chance to freely express themselves on each of the questions without any limitation. The administration of the questionnaire was done manually by the researcher by handing the questionnaire over to the respondents to solicit their views. This method of data collection gave respondents the privacy and confidence in addressing their individualistic experiences and perceptions on the evaluation of the efficiency of fingerprint capturing and matching techniques adopted in the Ghana Police Service.

3.4.1 Sources of Data

Two sources of data can be for the study, namely primary and secondary data. However, the major source of data for this study was the primary data. Primary data is usually collected by an investigator for the first time, right from the beginning to an end. The advantages of obtaining a primary data was that it renders the data more reliable, authentic and also very objective.

3.4.2 Pilot Study

Prior to the data collection for this study, prepared questionnaires were administered to 10 Criminal Investigation Department (CID) officials who were not to be included in the entire study. The pilot

test was focused on identifying relevant problems that were likely to be encountered during the actual administration of the questionnaire. The appropriate responses were dealt with prior to the administration of the questionnaire for data collection.

3.5 Target Population

The target population for this study four hundred and forty-four (444) CID officials of the Ghana Police Service within the Ashanti Region. The researcher chose to research on Ghana Police Service within the Ashanti Region due to proximity and convenience issues.

3.6 Sample and Sampling Technique

In this study, a sample of C.I.D officials that were involved in the study were sampled using a simple random sampling procedure. This strategy gave an equal opportunity to every C.I.D official within the Ashanti Region of the Ghana Police Service to be included in the study regardless of their geographical location and portfolio. Sampling unit comprise both crime officers and their subordinates. Out of the entire C.I.D officials within the Ashanti Region of the Ghana Police Service, the total sample that was used for this study was 210 respondents. The Central Limit Theory argues that when you are conducting a research that involves a large population, the sample size to be representative of the population is 30. Therefore, selecting 210 was representative enough. The sampling size of this study is ascertained using the Yamane's sample size determination for proportions.

$$n = \frac{1}{1 + N(e)^2}$$

Where n is the sample size

N is the population size of the study; where there are 444 C.I.D officials within the target population.

e is the desired level of precision. Since the study is measured at 95% confidence level, e will be 0.05

Therefore,

$$n = \frac{444}{1 + 444(0.05)^2}$$

n = 210 C.I.D officials

The respondents were evenly obtained from the fourteen (14) major Ghana Police Divisions within the Ashanti Region. The Divisions were categorized into three zones: Zone A- Ashanti Central Division, Asokwa Division, Manhyia Division, Suame Division and Tafo Pankrono Division. Zone B- Ejisu Division, Effiduase Division, Konongo Division and Asante Mampong Division. Zone C-Obuasi Division, Bekwai Division, Nkawie Division, Offinso Division, Tepa Division.

3.7 Ethical consideration

The researcher sought for an approval letter from the Director of Human Resource - Ghana Police Service, Ashanti Region in order to be given permission to carry out the study in the institution. Names of respondents were not captured in the questionnaire when answering them and the purpose of the study was made known to the respondents before they started answering the questions.

3.8 Data Analysis

Descriptive statistics such as frequency, means, and standard deviations were carried out on the data. For all statistical tests, a p -value < 0.05 was considered significant. The statistical

calculations were performed using SPSS version 16.0. Subsequently, statistically generated results were represented with tables and charts for a clear understanding of the analysis.

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CHAPTER FOUR

RESULTS

4.1 Demographic Characteristics of Respondents

This section considered the demographic data on criminal investigators within the Ashanti Regional Command of the Ghana Police Service (Table 4.1). Out of the 210 respondents, 60% were males whereas 40% were females. Majority of the respondents, representing 41% were in the age classification of 31-40 years while the least respondents, representing 14% were within 51-60

years. All respondents had some level of formal education with 50% having secondary education and only 4% with postgraduate degree. Most of the respondents (45%) had over 9 years working experience as criminal investigators. The results revealed that over 80% of the respondents had used fingerprint technique in their investigations. The number of respondents who had used the fingerprint technique for 5-10 years (30%) was highest among the respondents. There were significant differences ($P < 0.05$) within all the variables measured. Additionally, significant differences ($P < 0.05$) were further observed between the various zones for the respective parameters.

Table 4.1 Demographic Characteristics of Respondents

Parameters	Zone A (%) N=75	Zone B (%) N=60	Zone C (%) N=75	Total (%) N=210	^a P-value
Gender					0.01
Male	56	72	57	60	
Female	44	28	43	40	
Age (years)					0.00
20-30	25	20	25	24	
31-40	40	50	36	41	
41-50	24	12	27	21	
51-60	11	18	12	14	

Level of Education					0.00
SHS	55	53	43	50	
HND	9	10	17	13	
Bachelor's Degree	28	35	36	33	
Postgraduate	8	2	4	4	
Working experience (years)					0.00
1-3	21	17	12	17	
4-6	16	23	13	17	
7-9	17	20	26	21	
Above 9	46	40	49	45	
Use of fingerprinting technique					0.01
Yes	95	87	63	81	
No	5	13	37	19	
Years of Use of Fingerprinting Technique					0.00
1-5	29	33	13	26	
5-10	27	27	33	30	
10-15	6	17	21	18	
Above 15	28	23	33	26	
^bP-value	0.02 ^a	0.01 ^b	0.01 ^c		

^aP- value represents comparison within each parameter; ^bP- value represents comparison between the different zones. Thus, Zone A compared with Zone B, produced p-value of 0.02^a; Zone A compared with Zone C produced p-value of 0.01^b; Zone B compared with Zone C produced pvalue of 0.01^c

4.2 The use of Fingerprint Capturing and Matching Techniques

The number of respondents and cases successfully prosecuted in 2018 using the fingerprint techniques at the Ashanti Police Service Command are shown in Table 4.2. Among the zones, it was observed that Zone B had the majority of respondents (84%) followed by Zone C (83%), and Zone A (77%) who used the fingerprint techniques in their criminal investigations. However, zone A (0.71%) recorded the highest percentage of successful cases linked to fingerprint technique as compared to Zone B (0.10 %) and Zone C (0.03 %). There were statistically significant differences ($P < 0.05$) within all the parameters, as well as between all the zones and by extension the different divisions with regard to the use of fingerprint capturing and matching techniques.

The attitude of respondents and management towards the use of fingerprint technique in the various zones were also observed (Table 4.3). The attitude was measured using a five-Likert scale; where 1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, and 5 – strongly agree. The statement “I seldom use fingerprint identification and matching technique in all my investigations (4.01 ± 1.05)” was the only indicator that was highly agreed on by the respondents. However, respondents disagreed with the statement that “My division organizes yearly training and workshop sessions on fingerprint identification and matching technique (2.37 ± 1.35)”. Additionally, the respondents were in agreement with the statement “I always recommend the use of fingerprint identification and matching technique in investigations to my colleagues (3.70 ± 1.11)” The respondents remained neutral on the other statements without agreeing or disagreeing to such indicators.

Table 4.2 Use of Fingerprint Capturing and Matching Techniques by Divisions

Parameters						
Zone	Division	Investigators using fingerprint techniques (%) N = 210	^a Pvalue	Cases recorded to in 2018 (Cases linked fingerprint techniques)	Percentage of cases linked to fingerprint techniques (%)	^b Pvalue
A	Asokwa	87	0.01	2,024 (5)	0.25	0.02
	Manhyia	93		1,623 (23)	1.42	
	Suame	67		2,099 (11)	0.52	
	Ashanti- Central	80		3,011 (31)	1.03	
	Tafo-Pankrono	60		1,324 (2)	0.15	
					0.71	

	Total	77		10,081 (72)		
B	Ejisu	87	0.03	901 (1)	0.11	0.00
	Effiduase	87		677 (0)	0	
	Konongo	87		788 (0)	0	
	Mampong	73		808 (0)	0	
	Total	84		3,174 (1)	0.03	
C	Obuasi	87	0.003	1,075 (1)	0.09	0.00
	Bekwai	73		479 (0)	0	
	Nkawie	80		347 (0)	0	
	Offinso	87		577 (0)	0	
	Tepa	87		433 (2)	0	
	Total	83		2,911 (3)	0.10	

^aP- value represents comparison within each zone with regard to the number of investigators using fingerprint technique; ^bP- value represents comparison within each zone with regard to the number of successful cases linked to fingerprint technique.

Table 4.3 Attitude towards the use of fingerprint technique application

Variable	N	Mean ± SD
I seldom use fingerprint identification and matching technique in all my investigations	170	4.01 ± 1.05
I always recommend the use of fingerprint identification and matching technique in investigations to my colleagues	170	3.70 ± 1.11
My division encourages me to use fingerprint identification and matching technique in all my investigations.	170	3.39 ± 1.26

I have used fingerprint identification and matching technique to link a suspect to a crime scene	170	3.38 ± 1.31
I have used fingerprint identification and matching technique to gain conviction in a misdemeanor case	170	3.27 ± 1.32
I use fingerprint identification and matching technique in all my investigations.	170	3.15 ± 1.27
The working environment for the use of fingerprint identification and matching technique in my division is good	170	2.76 ± 1.35
My division organises yearly training and workshop sessions on fingerprint identification and matching technique	170	2.37 ± 1.35

4.3 Impact of Fingerprint Capturing and Matching Techniques on Criminal Investigations

The impact of fingerprint technique application on criminal investigations as observed by the respondents is presented in Table 4.4. The results showed that generally all the positive impact statements were highly agreed upon by the respondents with a mean range of 3.46 ± 1.37 - 4.08 ± 1.20 . Some of these statements included: “It has increased my knowledge in modern investigations (4.08 ± 1.20)”, “It enhances productivity in criminal investigations (4.04 ± 1.18)”, “It speeds up criminal investigations (4.04 ± 1.23)” and “It reduces ambiguity during prosecution and criminal investigations (4.03 ± 1.28)”.

Table 4.4 The impact of fingerprint technique application on criminal investigations

Variable	N	Mean ± SD
It has increased my knowledge in modern investigations	170	4.08 ± 1.20
It enhances productivity in criminal investigations	170	4.04 ± 1.18
It speeds up criminal investigations	170	4.04 ± 1.23
It reduces ambiguity during prosecution and criminal investigations	170	4.03 ± 1.28

It has increased cooperation amongst investigators	170	3.77 ± 1.25
It has created a reliable and stress –free environment for criminal investigators	170	3.69 ± 1.24
It has reduced connivance during criminal investigations	170	3.68 ± 1.30
It has reduced the number of criminal cases in the division.	170	3.46 ± 1.37

4.4 Challenges Associated with the Use of Fingerprint Capturing and Matching Techniques

Irrespective of the importance of using fingerprint techniques, it is associated with some challenges (Table 4.5). The level of agreement to the challenges associated with the use of the technique ranged from 2.01 ± 1.03 to 3.53 ± 1.52 . The predominant challenge to the use of fingerprint technique was the inadequate availability of resources (3.53 ± 1.52), whereas the least challenge to the use of fingerprint technique was the capability of the fingerprint technique not producing required results (2.01 ± 1.03).

Table 4.5 The challenges associated with the application of fingerprint techniques on criminal investigation

Variable	N	Mean \pm SD
Inadequate resources available at my division	170	3.53 ± 1.52
There is inadequate fingerprint capturing and matching equipment in my division	170	3.33 ± 1.54
Infrastructure for the fingerprint capturing and matching techniques is poor in my division	170	3.27 ± 1.56
There is less training for officials who use such techniques	170	3.26 ± 1.44

The fingerprint capturing and matching techniques are difficult to use	170	2.55 ± 1.46
My supervisors do not encourage us to use the fingerprint capturing and matching techniques	170	2.45 ± 1.46
The fingerprint capturing and matching techniques delay the entire criminal investigation process	170	2.37 ± 1.39
The fingerprint capturing and matching techniques can be easily manipulated by criminal investigators	170	2.20 ± 1.29
The fingerprint capturing and matching techniques do not produce the required results	170	2.01 ± 1.03

CHAPTER FIVE

DISCUSSION

Criminal investigators within the Ashanti Regional Command had 60% males and 40% females which was similar to the study conducted on the personnel of Ghana Police Service in Accra, with 61% males and 39 % females (Sam, 2013). The situation can be attributed to the fact that the

workload on investigators are huge, hence the observed high numbers of males compared with females. The results also supported the statement by Armstrong (2006), that most females are involved in jobs with less use of physical strength. Most of the criminal investigators were below 40 years. Erickson (1994), labelled age groupings as young adulthood (20-30), middle adulthood (31-45), and late adulthood (46 and above). According to these age classifications, the present study revealed that the criminal investigators within the Ashanti Regional Command were within their young and middle adulthood stages which had the potential to increase the productivity of the Ghana Police Service. The working experiences of personnel synchronized with the use of fingerprinting capturing and matching technique. The high retention rate of personnel can be attributed to the fact that there are inadequate alternative jobs available in Ghana. The results supported Bentil's (2008) assertion that high unemployment rate could lead to most employees staying with one company for longer period.

There is a clear indication, however, that the use of fingerprint capturing and matching techniques in criminal investigations was generally low across all the various zones. None of the zones was able to link the technique to up to 1.0% of their successfully prosecuted crime cases. The situation is attributed to the fact that personnel rarely use fingerprint capturing and matching techniques as a result of inadequate resources for its use. Moreover, training and workshop sessions on fingerprint technique applications are barely organised for personnel. Hence, the inability of the investigators to link most suspects to the crime using the technology and will automatically not encourage other colleagues to use it in their operations.

Irrespective of the low use of fingerprint technique in criminal investigations in the various divisions, the impact of the technique on investigations as acknowledged by the personnel was

quite massive. Thus the technique can increase the knowledge of personnel in modern investigations, enhanced productivity, speed up criminal investigations, and reduced ambiguity during prosecution and criminal investigations. Globally, the use of fingerprint technologies has yielded positive impacts on law enforcement institutions (Zalman, 2011). Nevertheless, an assessment of the flaws of the technology was dependent on the interventions of the police units. Aside the superior nature of automated fingerprint systems over manual ones, the manual fingerprint system cannot be discarded outright since technologies are fallible and in cases of malfunctioning, investigators can resort to the manual system (Moses, 2011). Therefore, the full application of fingerprint technique at the Ashanti Regional Command would have positive impacts on the activities of investigators which will translate into overwhelming organizational productivity.

Challenges associated with the use of fingerprint capturing and matching techniques are quite enormous ranging from those associated with personnel, management and institutional lapses.

The predominant challenges confronting the application of the technique in the Ashanti Regional Command included inadequate resources available at the divisions, inadequate fingerprint capturing and matching equipment, poor infrastructure for the fingerprint techniques and less training for personnel.

So in totality, the present study has showed the need to upgrade resources for fingerprint techniques at the Ashanti Region Command, improve infrastructure and organize more advance training for personnel in order to successfully prosecute cases linking suspects to their fingerprints. The findings also revealed that the region is well endowed with personnel capable of using the technology to the benefit of the people. Additionally, criminal investigations in the region have

not fully taken advantage of the fingerprint technique due to some systemic lapses in the area. The data further provided the opportunity for the study to be extended to other regions to have a clear picture of the situation in Ghana.

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CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The criminal investigators with technical knowledge on the application of fingerprint techniques across all the divisions were more than 75%; however, only few cases (at most 0.71%) were successfully prosecuted by these investigators using the technique. The investigators also had a lukewarm attitude towards the use of the technique even though they highly appreciated the positive impact (approximately 4.00 ± 1.20). Some of the significant impacts included enhancement of productivity, speeding of criminal proceedings and reduction in ambiguity during

criminal investigations. The major challenge to the application of fingerprint technique in the Ashanti Regional Command was the inadequate availability of resources (approximately 4.00 ± 1.52). Thus, the others are inadequate resources available at divisions, inadequate fingerprint capturing and matching equipment at divisions, poor infrastructure for the fingerprint capturing and matching techniques, and less training for personnel.

In summary, the present study has revealed that the use of fingerprinting in identifying criminals at Ashanti Regional Police Command was at its infant stage. The findings also provided the baseline information in the application of fingerprint technique in the region and also highly supported the call for the need to strengthen the use of the technique to facilitate criminal investigations in Ghana.

6.2 Recommendations

Amidst the milestones achieved in the present study, further assessment is urgently required to fully understand the effectiveness on the use of fingerprinting and forensic technology in the Ghana Police Service and other related institutions. Therefore, it is highly recommended that:

- Further studies should be carried out across other regions of the country to ensure a holistic assessment of fingerprint and criminal identification in the Ghana Police Service.
- Moreover, the use of other neglected forensic techniques such as latent lip identification in criminal investigations of the Ghana Police Service should be investigated.

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APPENDIX QUESTIONNAIRE KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

QUESTIONNAIRE ON “FINGERPRINTING AND CRIMINAL IDENTIFICATION IN GHANA – A CASE STUDY OF ASHANTI REGIONAL CRIMINAL INVESTIGATION DEPARTMENT

This questionnaire has been developed to evaluate the efficiency of fingerprint capturing and matching techniques adopted in the Ghana Police Service. Please be informed that this study is purely academic and that all information obtained shall be kept with utmost confidentiality. The outcome of this research may be used for academic and general purposes such as research reports, conference papers or books. Please tick/state where appropriate. Thank you for your acceptance

INSTRUCTION: Please fill the spaces provided. Mark (✓) where applicable and specify where necessary.

SECTION A: SOCIO-DEMOGRAPHIC DATA

1. Sex: a. Male ☐ b. Female ☐
2. Age: a. 20 – 30 years ☐ b. 31 – 40 years ☐ c. 41 – 50 ☐ d. 51-60 ☐ 3. What is your highest level of education? Please select the most appropriate.
a. Senior High ☐ b. HND ☐ c. Bachelor's Degree ☐ d. Post Graduate Degree ☐
e. Other (Please Specify) 4. Division
.....
5. How long have the company been working as a Criminal Investigator?
a. 1-3 years ☐ b. 4-6 years ☐ c. 7-9years ☐ d. Above 9 years ☐ 6. Do you use fingerprint identification in your criminal investigations?
a. Yes ☐ b. No ☐
7. If Yes in question 6, how long have you been using a fingerprint identification machine in your division
a. 1-5 years ☐ b. 6-10 years ☐ c. 11 – 15 years ☐ d. Above 15 years ☐

SECTION B: USE OF FINGERPRINT IDENTIFICATION AND MATCHING TECHNIQUE

Based on your personal experiences as a CID of your Division, please indicate to what extent you agree or disagree with each statement below. Using the Likert Scale where Strongly Disagree – 1, Disagree – 2, Neutral – 3, Agree – 4, Strongly Agree – 5.

	SD 1	D 2	N 3	A 4	SA 5
1. I use fingerprint identification and matching technique in all my investigations.					
2. I seldomly use fingerprint identification and matching technique in all my investigations					
3. I have used fingerprint identification and matching technique to gain conviction in a misdemeanor case					
4. I always recommend the use of fingerprint identification and matching technique in investigations to my colleagues					
5. My division encourages me to use fingerprint identification and matching technique in all my investigations.					
6. The working environment for the use of fingerprint identification and matching technique in my division is good					
7. My division organises yearly training and workshop sessions on fingerprint identification and matching technique					
8. I have used fingerprint identification and matching technique to link a suspect to a crime scene					

SECTION C: IMPACT OF EXISTING FINGERPRINT CAPTURING AND MATCHING TECHNIQUES ON CRIMINAL INVESTIGATIONS

Based on your personal experiences as a CID of your Division, please indicate to what extent you agree or disagree with each statement below. Using the Likert Scale where Strongly Disagree – 1, Disagree – 2, Neutral – 3, Agree – 4, Strongly Agree – 5.

	SD 1	D 2	N 3	A 4	SA 5
1. It enhances productivity in criminal investigations					
2. It speeds up criminal investigations					
3. It reduces ambiguity during prosecution and criminal investigations					
4. It has reduced connivance during criminal investigations					
5. It has reduced the number of criminal cases in the division.					
6. It has created a reliable and stress –free environment for criminal investigators					
7. It has increased cooperation amongst investigators					
8. It has increased my knowledge in modern investigations					

SECTION D: CHALLENGES ASSOCIATED WITH THE FINGERPRINT CAPTURING AND MATCHING TECHNIQUES

Based on your personal experiences as a CID of your Division, please indicate to what extent you agree or disagree with each statement below. Using the Likert Scale where Strongly Disagree – 1, Disagree – 2, Neutral – 3, Agree – 4, Strongly Agree – 5.

	SD 1	D 2	N 3	A 4	SA 5
1. The fingerprint capturing and matching techniques are difficult to use					
2. The fingerprint capturing and matching techniques delay the entire criminal investigation process					
3. The fingerprint capturing and matching techniques can be easily manipulated by criminal investigators					
4. Infrastructure for the fingerprint capturing and matching techniques is poor in my division					
5. The fingerprint capturing and matching techniques do not produce the required results					
6. My supervisors do not encourage us to use the fingerprint capturing and matching techniques					
7. There is less training for officials who use such techniques					
8. There is inadequate fingerprint capturing and matching equipment in my division					
9. Inadequate resources available at my division					

Thank you for your cooperation

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