APPROVAL SHEET

In partial fulfilment of the requirements for the degree Bachelor of Science in Computer Science, this thesis titled **"eFingerMatch:** ***A Mobile Application for Fingerprint Matching*****"** submitted by **Clara D. Dimaunahan, Erika Brenda M. Lontoc, Wendy P. Lota,** and **Jhesa D. Macalalad** is hereby recommended for oral examination.

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Defended in an oral examination before a duly constituted panel with a grade of
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eFingerMatch*: A Mobile Application for Fingerprint Matching*

A Thesis

Presented to

the Faculty of College of Computer Studies

Lyceum of the Philippines University – Batangas City

In Partial Fulfilment

of the Requirements for the Degree

Bachelor of Science in Computer Science

by:

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Clara Dimaunahan

Erika Brenda Lontoc

Wendy Lota

Jhesa Macalalad

DEDICATION

We dedicate this piece of work to our Dean Dr. Roselie B. Alday, for her guidance, consideration, and developed our skills, ideals and aspiration.

To our loving parents and relatives who help us financially and emotionally to make all of this possible.

To our research team members who gave their full cooperation for this study, this will not be done without our teamwork.

And most especially to our Almighty God, for giving us the strength and will in making this research possible.

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LIST OF FIGURES

eFingerMatch*: A Mobile Application for Fingerprint Matching*

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Abstract

Fingerprints are classified as one of biometrics form used to recognize a person and validate his/her uniqueness. Researchers found out that manual way in fingerprint identification is too difficult for examiners. The project developed a mobile application that will help fingerprint examiners like criminology students and investigators to easily match two fingerprints by using an algorithm in a mobile application. The researchers designed an application in matching fingerprints by capturing their images using built-in phone camera and give their matching scores. The method used in matching fingerprint images was Minutiae-based matching Algorithm through Sift and Surf and Image Enhancement Algorithm. It automatically converted the images into black and white and enhanced them to detect points of comparison. When the images have been converted, it counts the number of points to give their matching scores, which have been the basis if the images match or not. This mobile application is available for android operating system only. The programming language used by the researchers is Java. The application resulted to 98-100 percent accuracy in pre-processed image and 14-19 percent accuracy in on-the-spot process (Matched images), 11-12 percent accuracy in pre-processed image and 0-1 percent accuracy in on-the-spot (Mismatched Images). It is recommended that the application be improved by adding more features such as saving profile array in database for future matching and more.

Keywords

Fingerprint, Minutiae-based Matching Algorithm, Sift and Surf, Image Enhancement Algorithm

I. Introduction

A smart phone nowadays is very in demand. Most people cannot even leave their houses without their smart phone, a tool to communicate with the person they want to. A mobile application is an application that is installed in mobile phones. There is one mobile application that has not yet existed, i.e, fingerprint matching. In traditional/manual way of getting the match of fingerprints, it is way much difficult than this application-to-be. It should be step by step and details by details. Manual way must perform first the ACE-V (analysis, comparison, evaluation, verification) method to find the match. Researchers decided to make a mobile application that can directly match fingerprint images being captured by the built-in camera of smartphone or a pre-processed image that are already stored in the gallery, import them and convert directly to black and white and have a confirmation between the images if they are matched or not by detecting the found points and give their matching score. All people have their own fingerprints which are reliable means of identification. According to the forensic science, no two people can have the same fingerprint. Each fingerprint is unique and exclusive to each person. Fingerprints serve as basis for any criminal incident.

According to Alilou (2013), matching a fingerprint is still a formidable problem for well-founded individual authentication because of the complex distortions involved in two impressions of the same finger. Since the clear majority of fingerprint matching algorithms primarily rely on minutiae matching, minutiae information is regarded as highly significant features for Automatic Fingerprint Recognition System.

In analyzing fingerprint there is so much work to do to identify if the fingerprint matches another fingerprint, especially without computers' help. Fingerprint examiners no longer need to use the manual procedure because eFingerMatch will do the manual task. It can be easier for them because they can save time and cost with the same quality.

2.0 The Research

2.1 Objectives

The main objective of the study is to create a mobile application that allows the user to capture fingerprint images and match with each other.

This study specifically aims to:

1. Create a proof of concept that will allow the user to capture fingerprint images and match them using android device.
2. Use minutiae-based fingerprint matching through sift and surf algorithm and fingerprint image enhancement algorithm in the development of the application.
3. Use Java programming language with Java packages in developing the application.

2.2 Review of Literature

2.2.1 Fingerprint

According to Collins (2006), the fingers, palms of the hands, toes and the soles of the feet are covered with tiny lines known as friction ridges. These tiny ridges aid in creating fiction on the hands and feet, which makes it easier for us to hold small objects and other things. These ridges appear on the fetus usually around 100 and 120 days after conception. They are one of the first important characteristics of life that human body takes form before birth, and one of the last to disappear after death. There is no change in these ridges throughout one's lifetime, except than normal growth and permanent scarring. Criminals tried their best and have made many attempts to change their individual fingerprint classification. However, none has been successful in doing so.

Fingerprints are even more unique and exclusive than DNA, the genetic material in the cells in our whole body. Although identical twins can share the same DNA, or at least most of it, it is impossible for them to have the same fingerprints.

There are three basic fingerprint patterns that can be seen. The first basic fingerprint pattern is called Loop, a pattern that has only one delta. The second basic fingerprint pattern is called a whorl, a pattern that has two deltas. The last basic fingerprint pattern is called an arch, in which no deltas exist.

Identytech Solutions America, LCC (2016) stated that a friction ridge is a raised portion of the epidermis on the palmar (palm and fingers) or plantar (sole and toes) skin, consisting of one or more connected ridge units of friction ridge skin. These ridges are sometimes known as "dermal ridges" or "dermal papillae".

A fingerprint is the pattern of ridges and related characteristics found on the finger pads, the fleshy soft parts of the fingers used primarily for touching and gripping. Each individual's fingerprints are unique and stay unchanged throughout life. According to Sir Francis Galton, the nineteenth-century English anthropologist, the chances of two fingerprints being practically identical are as small as 64 billion to one.

2.2.2 FINGERPRINT ANALYSIS AND ITS PURPOSE

According to Identytech Solutions America, LCC (2016), the process of fingerprint identification (also referred to as individualization) occurs when an expert (or an expert computer system operating under threshold scoring rules) determines that two friction ridge impressions originated from the same finger or palm (or toe, sole) in an individual to the exclusion of all others. It is the process of comparing multiple questioned and known friction skin ridge impressions from fingers, palms, and toes to determine if the impressions are from the same finger (or palm, toe, etc.).

Since the original method of determining skin ridge impressions is accomplished by rolling a finger in ink and transferring the ink to a fingerprint card, the modern method uses a computer to scan the images of the fingerprints followed by a wide range of benefits. With this method, the fingerprinting is completed without the clutter and mess of the traditional inking system.

The fingerprints of two humans are not entirely alike. This makes the process of fingerprinting a very widely accepted method of identifying certain individual, whether alive or dead. The identification process is completed in modern forensic labs by placing the most recent image of a known set of fingerprints of an individual into a computer. The computer is linked to a site that stores every set of fingerprints ever taken on file; if a match is detected, the computer will register the prints to a known person.

According to the study of Majhi and Singh, fingerprint recognition system has advantages and these are: (a) Most of the population has legible fingerprints, (b) Prove that no two people can have the same fingerprints (c) Fingerprint cannot be changed, and are formed in our fetal stage, (d) Most accurate forms of biometrics, and (e) Fingerprints cannot be compared to others because they are unique and hence a good option.

2.2.3 Steps in Fingerprint Analysis

As stated by Sheridan (2013), a person who is at the crime scene or the thing he/she touches can be identified by the fingerprint left and can be an evidence whether a person is a suspect or a victim. However, defense attorneys must know that locating and identifying fingerprints are far different from science when it comes to techniques. Furthermore, crime scene technicians and fingerprint examiners are extremely important to have knowledge of the various techniques used in fingerprint collection to make the analysis successful.

According to Sheridan, these are the steps in fingerprint analysis:

Step 1: Locating the fingerprint

Locating a fingerprint often desires paying attention and estimated search. However, it is easy to find a fingerprint if the print is visible to the naked eye. The more intricate searches take place when the print is present on a surface but not visible. The amount of time and effort dedicated by the investigators in locating the print is usually recognized by the type of fingerprint left behind.

Prints that are visible to the naked eye and are easy to locate is the latent print. Another print that is easy to find is the plastic print; it is when someone touches an object such as wax, butter, or soap that leaves a three-dimensional result of the finger on the object. The most common type of print is the latent print; it requires the most effort in locating because it is invisible.

There are two-phase processes that the investigators pursue when searching for fingerprints. Since the patent and plastic prints are visible, looking for them is the first phase. Flashlight is usually used in this phase. According to scientific evidence, blind search for latent prints is the second phase.

The type of surface being searched for fingerprints often determines the technique employed by investigators. Types of surface include nonporous, porous, human skin, and textured surfaces.

Step 2: Photographing the fingerprint

It is necessary that photograph is lifted after locating the print. A photograph captures where the print is located in comparison to other objects and captures the orientation of the print. In addition, it can also be used to compare and possibly match the print to its source and one way to recognize patent or plastic print. To avoid intruding the evidence, photographing the prints section at the crime scene is highly essential.

Step 3: Lifting the fingerprint

"Lifting the fingerprint" literally means to generate a persistent impression of the fingerprint. It can be accomplished on either flat surfaces or round surfaces. Lifting used a rubber tape that leaves an imprint on the tape. Often, a flat object, such as a ruler, will be slowly swiped across the top of the tape to ensure that there are no bubbles or ripples in the tape that will affect the imprint. Next, to restrain interruption of the print, a plastic cover is placed on the adhesive side of the tape and the tape is carefully peeled off the surface.

Step 4: Comparing the fingerprint

Close examination of the features of the fingerprints is the final step of analysis. The fingerprint examination process utilizes the ACE-V method which stands for Analysis, Comparison, Evaluation and Verification to compare a print collected from a crime scene to a set of known prints.

To be able to find a match of fingerprints through computer database, there is a system created and called Automated Fingerprint Identification System (AFIS).

The Fingerprint Analysis Process

According to National Forensic Science Technology Center (2013), ACE-V method is used by fingerprint examiners to determine each print.

Analysis includes evaluating a print to figure out whether it can be utilized for a correlation. The examination may likewise reveal physical components, for example, recurves, deltas, creases and scars that encourage show where to start the correlation.

Comparisons are performed by an investigator who sees the known and suspect prints one next to the other. The expert looks at details attributes and areas to figure out whether they coordinate. Known prints are regularly gathered from people of interest, victims, others present at the scene or through a search of at least one unique finger impression databases, for example, the FBI's Integrated Automated Fingerprint Identification System (IAFIS).

Evaluation is where the examiner chooses if the prints are from a similar source (recognizable proof or individualization), diverse sources (exclusion) or is uncertain.

Verification is the point at which another analyst autonomously breaks down, looks at and assesses the prints to either bolster or invalidate the conclusions of the first examiner. The examiner may likewise check the reasonableness of conclusions made in the investigation stage. Identifying fingerprint by manual process or the old process surely cost more of your time. You will also bring many materials to be used in determining the fingerprint match.

By the manual procedure of identifying the fingerprint it is done step by step, and detail by detail. Researchers decided to make an alternative way for the investigator to easily match the two fingerprints to make it simpler compare to the manual procedure. They make it a point that the app does the checking of every point and detail in a technical way. Different ways that mobile application does is to match example by capturing the images of the fingerprints or a pre-process image and automatically converts it to black and white, then the image enhancement algorithm makes the images clearer and the minutiae-based algorithm finds the points of the fingerprints and gives their matching score.

2.2.4 Algorithm 1: Minutiae-Based Matching

As indicated by Begum, et al. (2012) Minutiae-based matching is the most popular and widely used technique, being the premise of the unique finger impression examination made by fingerprint examiners. Details are removed from the two fingerprints and stored as sets of points in the two-dimensional plane. Minutiae-based matching basically comprises finding the arrangement between the template and the input minutiae feature that result in the most extreme number of particulars pairings.

Begum and his companions propose a fingerprint minutia matching technique, which matches the fingerprint minutiae by using both the local and global structures of minutiae. The local structure of a minutia describes a rotation and translation invariant feature of the minutia in its neighborhood. It is utilized to discover the correspondence of two particular sets and increment the unwavering quality of the global matching. The global structure of minutiae reliably determines the uniqueness of fingerprint. Therefore, the local and global structures of minutiae together provide a solid basis for reliable and robust minutiae matching. The proposed minutiae matching scheme is suitable for an online processing due to its high processing speed. Experimental results show the performance of the proposed technique.

Sift Algorithm

Hamid et al. (2012), stated that detector siftha mainly includes four major stages: scale-space extreme detection, key point localization, orientation assignment and key point descriptor. The first stage used difference-of-Gaussian function (DOG) to identify the potential interest points, which were invariant to scale and orientation. DOG was used instead of Gaussian to improve the computation speed. In the key point localization step, the low contrast points are rejected and the edge response is eliminated. Hessian matrix was used to compute the principal curvatures and eliminate the key points that have a ratio between the principal curvatures that are greater than the ratio. An orientation histogram was formed from the gradient orientations of sample points within a region around the key point to get an orientation assignment. According to the paper’s experiments, the best results were achieved with a 4 x 4 array of histograms with 8 orientation bins in each. So, the descriptor of SIFT that was used is 4 x 4 x 8 = 128 dimensions. The key point descriptors are calculated from the local gradient orientation and magnitudes in a certain neighborhood around the identified key point. The gradient orientations and magnitudes are combined in a histogram representation from which the descriptor is formed.

Surf Algorithm

Hamid et al. (2012) also stated that surf algorithm is employed in slightly different way of detecting image features. SIFT builds an image pyramids by filtering each layer with Gaussians of increasing sigma values and taking the difference. On the other hand, SURF creates a “stack” without 2:1 down sampling for higher levels in the pyramid; a matter that results in having images of same resolution. Due to the use of integral images, SURF filters the stack using a box filter approximation of second-order Gaussian partial derivatives. This is because the integral images allow the computation of rectangular box filters in a near constant time. SURF has been published by Bay to tackle the problem of point and line segment correspondences between two images of the same scene or object. The latter in turn can be part of many computer vision applications. Approach can be divided into three main steps. First, key points are selected at distinctive locations in the image, such as corners, blobs, and T-junctions. Next, the neighborhood of every key point is represented by a feature vector. This descriptor should be distinctive. At the same time, it should be robust to noise, detection errors, and geometric and photometric deformations. Finally, the descriptor vectors are matched among the different images. Key points are found by using a so-called Fast-Hessian Detector that is based on the approximation of the Hessian matrix of a given image point. The responses to Haar wavelets are used for orientation assignment before the key point descriptor is formed from the wavelet responses in a certain surrounding to the key point. Therefore, the SURF constructs a circular region around the detected key points. Second, the SURF descriptors are constructed by extracting square regions around the key-points. Such a process results in a descriptor of sixty-four-length.

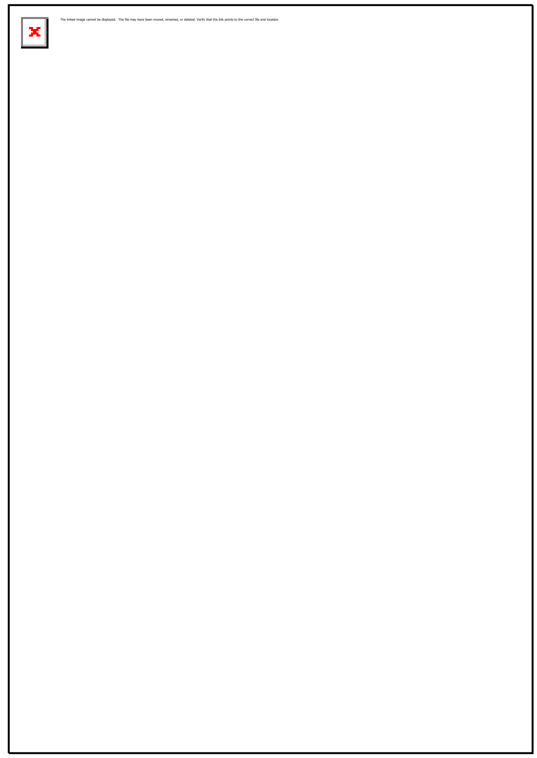

Figure 1. Diagram of Minutiae-based matching through Sift and Surf Algorithm

2.2.5 Algorithm 2: Fingerprint Image Enhancement Algorithm

According to Naja et al. (2015), fingerprint enhancement can be conducted on either binary images or gray level images.

A binary ridge image is an image where all the ridge pixels are assigned a value one and valley pixels are assigned a value zero. However, after applying a ridge extraction algorithm on the original gray-level images, information about the true ridge structures is often lost depending on the performance of the ridge extraction algorithm. Therefore, enhancement of binary ridge images has its inherent limitations. In a gray-level fingerprint image, ridges and valleys in a local neighborhood form a sinusoidal-shaped plane wave which has a well-defined frequency and orientation. Fingerprint enhancement algorithm includes normalization, segmentation, orientation estimation, ridge frequency estimation, gabor filtering, binarization and thinning.

The flow diagram of fingerprint input image is as follows.

Figure 2. Diagram of fingerprint input image using fingerprint image enhancement
Source: http://www.ijircce.com/upload/2015/january/45_Fingerprint.pdf

A. Normalization

An input fingerprint image is normalized so that it has a pre-specified mean and variance. Normalization is used to standardize the intensity values in an image by adjusting the range of grey-level values so that it lies within a desired range of values.

B. Segmentation

Segmentation is the process of separating the foreground regions in the image from the background regions. The foreground regions correspond to the clear fingerprint area containing the ridges and valleys. The background corresponds to the regions outside the borders of the fingerprint area, which do not contain any valid information. When minutiae extraction algorithms are applied to the background regions of an image, it results in the extraction of noisy and false minutiae. In a fingerprint image, the background regions generally exhibit a very low grey-scale variance value, whereas the foreground regions have a very high variance. Hence, a method based on variance thresholding can be used to perform the segmentation.

C. Orientation Estimation

The orientation field of a fingerprint image defines the local orientation of the ridges contained in the fingerprint. The orientation estimation is a fundamental step in the enhancement process as the Gabor filtering stage relies on the local orientation in order to enhance the fingerprint image.

D. Ridge frequency estimation and Gabor Filtering

In addition to the orientation image, another important parameter that is used in the construction of the Gabor filter is the local ridge frequency. The frequency image represents the local frequency of the ridges in a fingerprint. The first step in the frequency estimation stage is to divide the image into blocks of size W * W. The next step is to project the grey-level values of all the pixels located inside each block along a direction orthogonal to the local ridge orientation.

E. Binarization and Thinning

Binarization is the process that converts a grey level image into a binary image. This improves the contrast between the ridges and valleys in a fingerprint image, and facilitates the extraction of minutiae. The binarization process involves examining the grey level value of each pixel in the enhanced image, and, if the value is greater than the global threshold, then the pixel value is set to a binary value one; otherwise, it is set to zero.

Thinning is a morphological operation that successively erodes away the foreground pixels until they are one pixel wide. A standard thinning algorithm is employed, which performs the thinning operation using two sub iterations.

2.2.6 PROGRAMMING LANGUAGE

Java programming language is used because of its platform independence, scalability, easy integration, implementation and upgrade. Sims stated that Java does not compile to native processor code but it depends on a "virtual machine" that comprehends an intermediate format called Java bytecode.

According to Conder et al. (2010), Java applications run within the bubble that is a virtual machine, which are isolated from the underlying device hardware. Therefore, a virtual machine can encapsulate, contain, and manage code execution in a safe manner compared to languages that operate in machine code directly. The Android platform takes things a step further. Each Android application runs on the (Linux-based) operating system using a different user account and in its own instance of the Dalvik VM. Android applications are closely monitored by the operating system and shut down if they do not play nice (e.g. use too much processing power, become unresponsive, waste resources, etc.). Therefore, it is important to develop applications that are stable and responsive. Applications can communicate with one another using well-defined protocols.

2.3 REVIEW OF RELATED STUDIES

2.3.1 Fingerprint Verification

According to Kovacs (2000), integration of various fingerprint matching algorithms is a viable method to improve the performance of a fingerprint verification system. Different fingerprint matching algorithms are often based on different representations of the input fingerprints and hence complement each other. We use the logistic transform to integrate the output scores from three different fingerprint matching algorithms. Experiments conducted on a large fingerprint database confirm the effectiveness of the proposed integration scheme.

An effective fingerprint verification system is presented. It assumes that an existing reference fingerprint image must validate the identity of a person by means of a test fingerprint image acquired online and in real-time using minutiae matching. The matching system consists of two main blocks: The first allows for the extraction of essential information from the reference image off-line, the second performs the matching itself online. The information is obtained from the reference image by filtering and careful minutiae extraction procedures. The fingerprint identification is based on triangular matching to cope with the strong deformation of fingerprint images due to static friction or finger rolling. The matching is finally validated by dynamic time warping. Results reported on the NIST Special Database four reference sets, featuring 85 percent correct verification (15 percent false negative) and 0.05 percent false positive, demonstrate the effectiveness of the verification technique.

2.3.2 Fingerprint Capturing

As stated by Teng et al. (2005), an apparatus and method for acquiring an image of a patterned object such as a fingerprint including a light refracting device, a focusing lens, a light source, and a biometric circuit for detecting the presence of a patterned object such as a fingerprint at the light refracting device. Incident light from the light source is projected through a light receiving surface of the light refracting device and is directly reflected off an imaging surface. The resulting image is projected through the focusing lens. The focusing lens has a diameter that is larger than the projection of the patterned object through the light refracting device.

2.4 Research Method

This chapter includes the methods and procedures used in this study. In order to accomplish the study, the researchers used SDLC (Software Development Life Cycle) Waterfall method to gather the information needed to develop the mobile application.

The researchers communicated with the College of Criminology to ask questions about their topics. They encountered students who are taking up BS in Criminology. The researchers asked questions to those students about what they know about the topic. The researchers decided to choose this topic because there is no existing application about matching fingerprints. They also conducted an interview with the Dean of Criminology and asked guides for this thesis. After knowing that fingerprint matching is done by a person in manual way, the researchers realized that this application would be something useful. To accumulate information, the researchers conducted research from books, web and other reference materials that can be used for this thesis.

Forensic Scene Investigator of SOCO and Criminology students who are enrolled in Criminalis 1 are the beneficiaries of this mobile application for easier fingerprint matching because they can already see the found points. They no longer need to use the manual way. They are just going to capture the images and the app automatically matches the two fingerprints and shows the found points and gives their matching score.

In developing this mobile application, the researchers used Java as programming language and minutiae-based matching algorithm through sift and surf that looks for the points in the ridges of the fingerprint and compares the minutiae found between the two images to calculate the result and determines if they match or not based on the given found points and matching percentage score. Another one is Image enhancement algorithm that enhances and clears the images of fingerprints for minutiae extraction as the algorithms to be used to develop the application. The basis for this application to be successful is the clarity of the fingerprint images and camera to be used. The application is developed using Android Studio, Android SDK and openCv and be used in any powerful android smartphones.

2.5 RESULTS AND FINDINGS

eFingerMatch is a mobile application that helps determine if the fingerprint is related or matched with another one. It will use the device camera and memory to perform its actions by implementing Image Enhancement Algorithm on the image, and count the fingerprint points and give their matching score. The investigators and criminology students can detect if your fingerprint is matched with the use of camera of mobile phones, with android as their Operating Systems (Lollipop and above), and through the use of Minutiae and Image segmentation. This mobile application has various ways to figure out their different percentages by detecting different ridges and valleys. There are two kinds of process “On the Spot” and the “Preprocess” Image. On the spot may have the accuracy of 0-1 percent while preprocess you may have the result of 11-12 percent in mismatch images. On the spot process of matched images they have an accuracy of 14-19 percent while in preprocess they an accuracy of 98-100 percent.

The eFingerMatch application must use Lollipop version and above. The RAM of the phone should be at least 3GB. In terms of sizes it will matter because of the different mobile phone screen sizes but the default size is Nexus 4. The fingerprint should be lightly pressed on the paper because if it is too hardly pressed it may not count clearly the points because the points may be covered by the ink that is not visible to the naked eye. The default camera of the phone will be used to capture the fingerprint.

However, this application has limitations. Crumpled Finger print is not advisable for the app. The device camera must have an auto-focus. Be sure to focus on the fingerprint before capturing the image. You should not take pictures on dark areas since proper lightning is required. It is also advised to make sure that the megapixels and size of the camera be adjusted to lower resolution so that the application can read the images efficiently.

If the user will use pre-processed image of fingerprints, they must be on the same source.

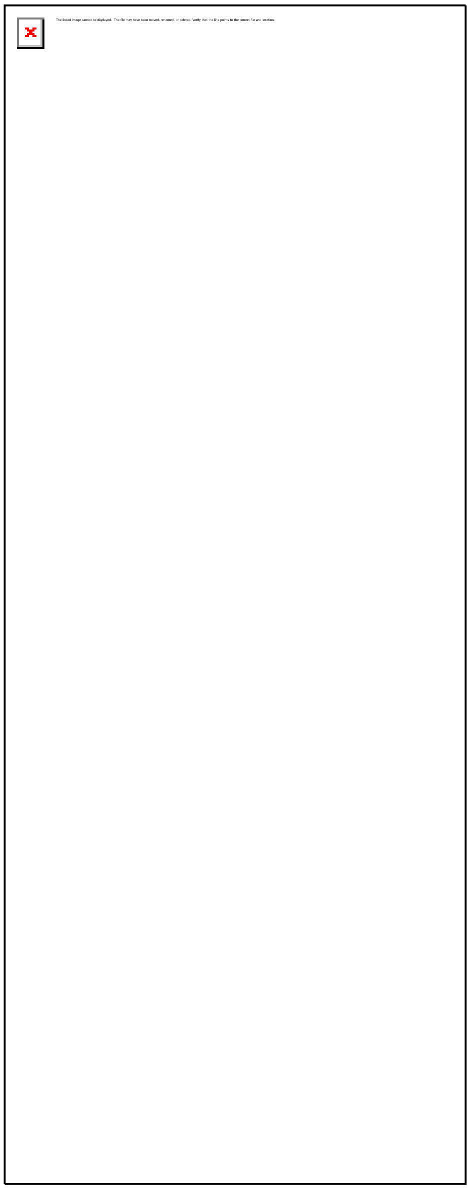

Figure 3. Graphical Presentation of the Application

Screenshots

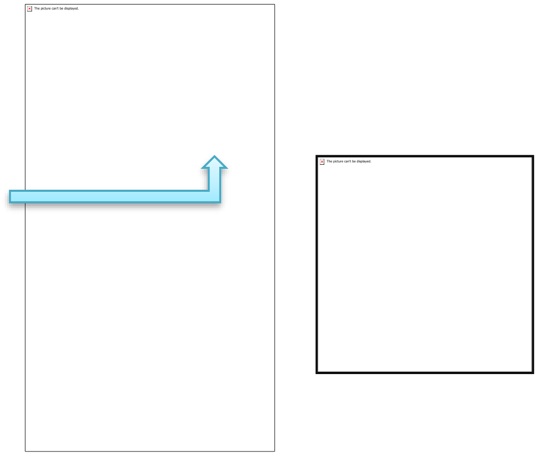

Figure 4. Home Screen (Icon)

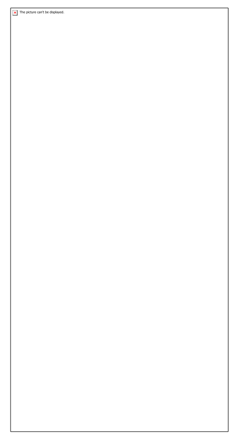

Figure 5. Splash/Opening Screen

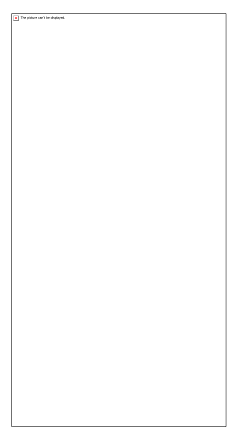

Figure 6. Main Menu

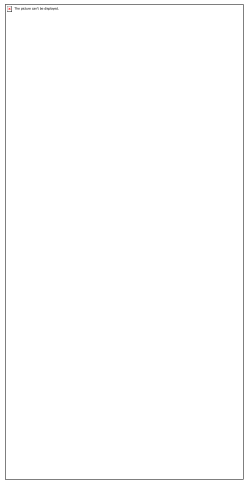

Figure 7. Import Screen

Figure 8. Selected Images Screen

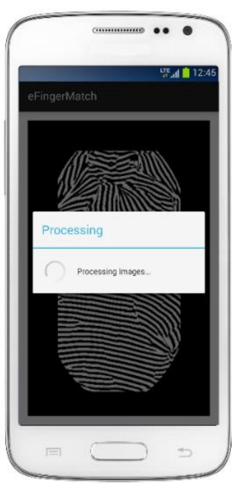

Figure 9. Processing Screen

Figure 10. Converted Black and White Image

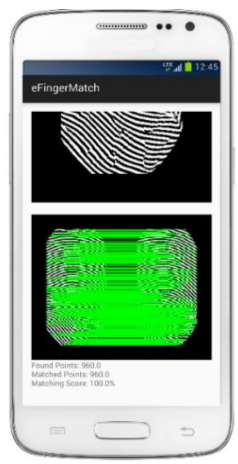

Figure 11. Matching Result Screen

Figure 12. Help Screen

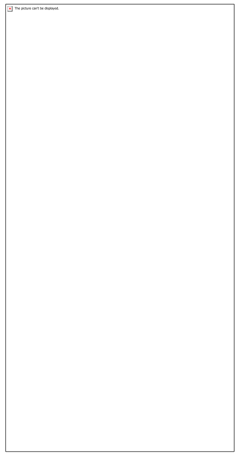

Figure 13. About Us Screen

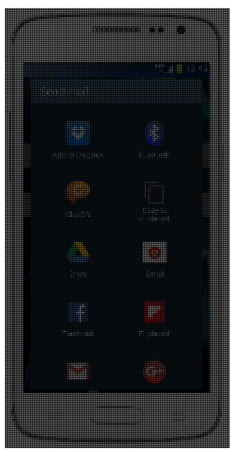

Figure 14. Feedback Screen

2.6 CONCLUSIONS

After the completion of eFingerMatch application, it has been found out that this application can detect points and can match two fingerprints by giving their matching score. This mobile application has been developed to lessen the activity of the investigators with the use of android phones. If the application will use the "On-the Spot" process in capturing images, the result points will be lessened compared with "Pre-processed" images that are already stored in the gallery. Matching score is more accurate and will give a 98-100 percent result. The proof that matching is working and functional is tested when two same images are used. Matched fingerprints can also be seen by the number of horizontal lines that appeared in the result.

2.7 RECOMMENDATIONS

This study can be a reference for future researchers who are into developing mobile application project using Android Studio as their IDE. Furthermore, it is recommended that the eFingerMatch Application can save array profile for future matching and improve the matching score of the images captured by the camera when its on-the-spot. Do field tests. Count the horizontal lines to find the points where they match because it is one of the layers to filter good points. Explore more about ISO biometric formats. Fingerprint images in gallery should have labels.

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