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Fingerprint Identification for Forensic Crime Scene Investigation

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Abstract: Fingerprints are the most widely used biometric feature for person identification and verification in the field of biometric identification. This paper presents the implementation of a minutiae based approach to fingerprint identification and verification of the fingerprint image captured at the crime scene. Digital evidence enhancement techniques, such as Fast Fourier Transform and Image Subtraction, have been described in detail.

Keywords: Fingerprint, Fast Fourier Transform, filtering, Fast Fourier Transform, Image Subtraction, minutiae

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I. Introduction

The evidence photographer is faced with a wide range of photographic challenges at crime scenes. Recording crucial evidence in the form of fingerprints, shoeprints, or other impressions is often problematic. These images may be extremely fragile as well as difficult to see. The background color or texture can easily overpower subtle detail. Curved, specular, or uneven surfaces may resist attempts to record all of the detail in one exposure. Lastly, exhibits bearing evidence can often be difficult or impossible to remove from the scene for photography in a controlled environment, without risking damage to the evidence. In most circumstances, conventional photographic procedures are used successfully to record such evidence discovered at crime scenes. The experienced photographer may employ oblique, tent or coaxial lighting, tilt and swing camera movements, or polarizing and contrast filters to obtain a suitable recording. Evidence at a crime scene is that the evidence is often masked behind backgrounds [1]. This makes it difficult for extracting key components from the evidence. Often times, the background color of the crime scene can overpower the faint detail of the evidence. Types of evidence that this can occur on is with finger prints and shoe prints at the crime scene. To correct this problem, image enhancement techniques can be used to obtain the relevant information that is needed for the investigators. The system was developed using Matlab. Providing all the necessary tools for designing and testing different filtering techniques.

II. Fingerprint Image Enhancement

The first step for image enhancement in this type of situation is to remove the regular patterns, or the background, from the image. The Fast Fourier Transform (FFT) is used to remove the regular patterns from the image. An example of removing the background through FFT is shown in fig. 1, which shows a finger print on a form of currency. By removing the wavy parts of the currency from the image, it's easier to collect the finger print [2].

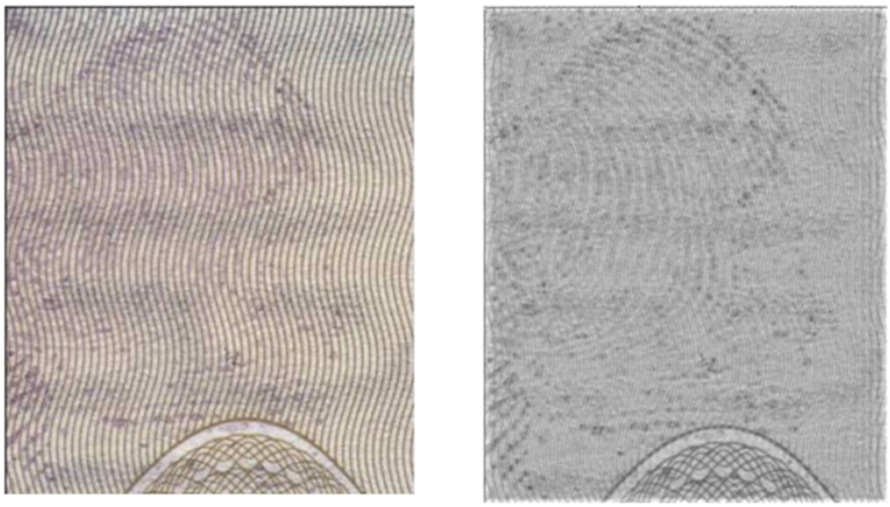

Fig. 1 Image before and after FFT to remove the background.

When a FFT is not suitable to the particular situation, the background can also be removed by finding regular patterns on the image and subtracting them from the original. This is done by finding a number of identifying marks on each image, lining the marks up, and subtracting the two images.

An example of background subtraction is given in Fig. 2 and Fig.3. This image is better suited for image subtraction than for FFT because the background is very complex and fairly random. After that there are many options to enhance the image to obtain the best possible picture of the forensic evidence. One such method is to invert the image and adjust it for contrast. Other corrections such as brightness and gamma adjustments can be applied if necessary [2].

Fig. 2 Image before image subtraction to remove the background

Fig. 3 Image after image subtraction to remove the background

III. Fingerprint Identification Using Minutiae Matching

Fingerprint image enhancement and minutiae matching are two key steps in an automatic fingerprint identification system. Fingerprint Identification is the method of identification using the impressions made by the minute ridge formations or patterns found on the fingertips. No two persons have exactly the same arrangement of ridge patterns, and the patterns of any one individual remain unchanged throughout life [3],[4]. Fingerprints offer an infallible means of personal identification. Other personal characteristics may change, but fingerprints do not. In general, we use minutiae such as ridge endings and ridge bifurcation to represent a fingerprint and do fingerprint matching through minutiae matching. Fig.4 shows Fingerprint Pattern Type

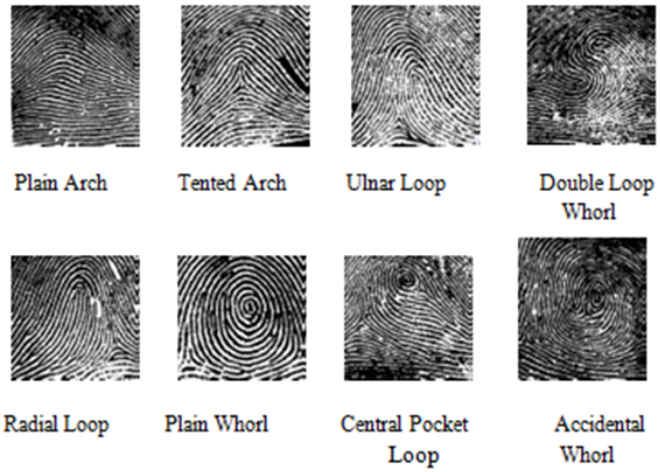

Fig.4 Fingerprint Pattern Type

This system consists of two phases template storing and matching phases. After using FFT or Image subtraction to get the fingerprint. In template storing phase, a fingerprint is acquired, enhanced using different algorithms, where after features of the fingerprint are extracted and stored in a database as a template. In the matching phase, a fingerprint is acquired, enhanced and features of the fingerprint are extracted, fed to a matching model and matched against template. This system is shown in fig.5.

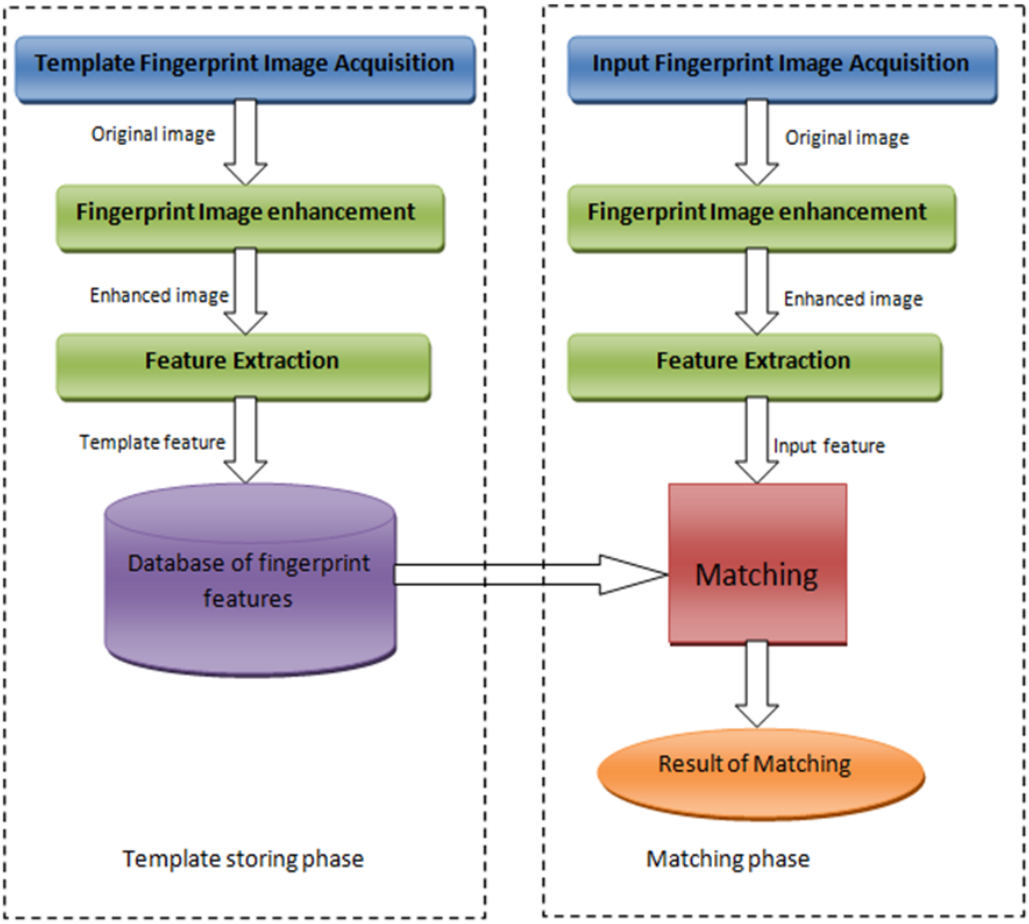

Fig.5 Flowchart of fingerprint identification system

Minutiae-based techniques first find minutiae points and then map their relative placement on the finger Fig.6 shows the basic and composite ridge characteristics (minutiae). However, there are some difficulties when using this approach. It is difficult to extract the minutiae points accurately when the fingerprint is of low quality [5],[6]. Also this method does not take into account the global pattern of ridges and furrows. For a good quality fingerprint feature extraction is much easier, efficient and reliable in comparison to a relatively lower quality fingerprint. The quality of fingerprints is degraded by skin conditions (e.g. wet or dry, cuts and bruises), sensor noise, non-uniform contact with sensor surface, and inherently low quality fingerprint images (e.g. those of elderly people, laborers) [7]. A significant percentage of fingerprints are of poor quality, which must be enhanced for the recognition process to be effective.fig.7 shows minutiae matching between two fingerprints.

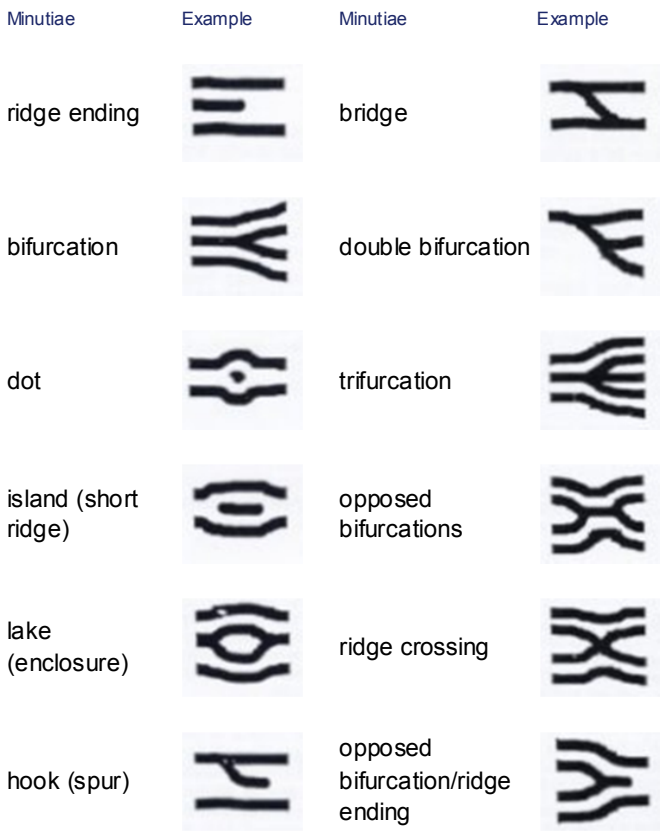

Fig. 6 Basic and composite ridge characteristics (minutiae)

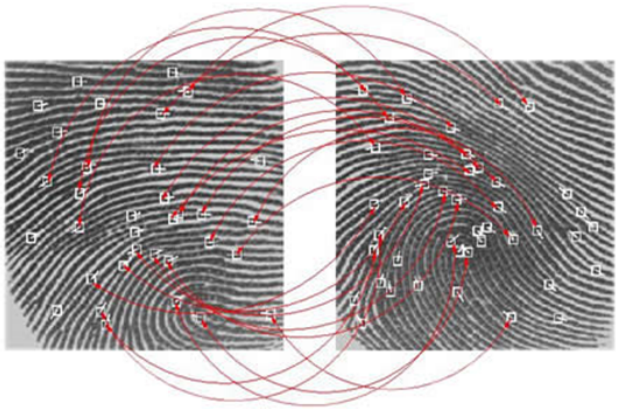

Fig.7 minutiae matching

A single finger impression may consist of isolated areas of ridge detail that are distinct and continuous, but lack sufficient detail independently upon which to base a conclusion of either elimination or identity. If the areas between these areas can be clarified so that the continuity of the ridges is unbroken, a significant opinion may be formed that would otherwise have not been possible.

IV. Conclusion

Image enhancement is a key tool for forensic investigators when searching for evidence at a crime scene. It can be invaluable for evidence that is faint and tough to make out. It is usually necessary for investigators to be able to get rid of the background, which can be done by FFT or background subtraction. Investigators can use many different options for further enhancement, including gamma corrections, contrast stretching, and histogram equalization. By doing these following methods, forensic investigators can obtain the best possible evidence from a crime scene. Also the paper presents an overview of the different steps involved in the development of fingerprint based person identification and verification using minutiae based system.

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