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Implementation of Latent Fingerprint Matching System

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ABSTRACT

"Biometrics" means "life measurement" .The term is usually associated with the use of unique physiological characteristics to identify an individual. Biometrics is used in computer science as a means of identification and access control. It is also used to identify individuals in groups that are under surveillance. Latent finger prints are inadvertent impressions left by fingers on surfaces of objects. The main difficulties in latent fingerprint matching are unclear ridge structure, small finger area, and large non-linear distortion while rolled fingerprint are of larger size and contain more minutiae. Latent fingerprint identification is of critical importance to law enforcement agencies in identifying suspects. While tremendous progress has been made in plain and rolled fingerprint matching, latent fingerprint matching continues to be a difficult problem. The eventual goal of research is to propose a system for matching latent fingerprints to rolled fingerprints that is needed in forensics applications. The system will match latent fingerprints to rolled fingerprints that is needed in forensics applications. In this paper we will apply latent fingerprint algorithm to develop a minutiae-based fingerprint matcher that takes into account the specific characteristics of the latent matching problem.The experimental results indicate that singularity, ridge quality map, and ridge flow map are the most effective features in improving the matching accuracy. The matching module consists of minutiae matching, orientation field matching.

Keywords: *Fingerprint; Minutiae; Latent Fingerprint Matching*.

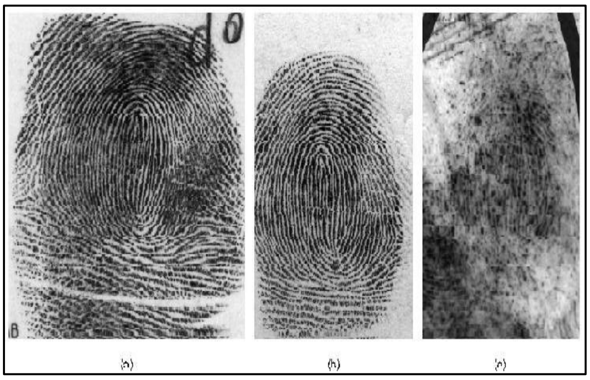
1.0 Introduction

Fingerprints are impressions that are created by ridges on the skin. When a person touches an object, the perspiration, oils and amino acids on the skin are transferred to the object, frequently, leaving an impression of the ridge pattern. This is called fingerprint. Fingerprint can be classified based on the type of capture as:

- Rolled fingerprint
- Plan fingerprint
- Latent fingerprint

Rolled and latent fingerprints are mainly used in forensic applications, whereas plain fingerprints are mainly used in commercial and government applications. Rolled fingerprints are obtained by rolling a finger from one side to the other ("nail-to nail") in order to capture all the ridge-details of a finger [12, 13]. Plain impressions are those in which the finger is pressed down on a flat surface but not rolled.

Rolled
Plain Latent



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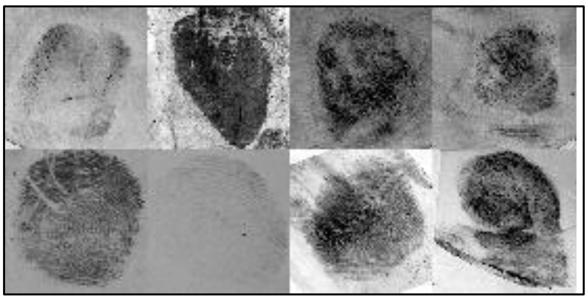
While plain impressions cover a smaller area than rolled prints, they typically do not have the distortion introduced during rolling. Both rolled and plan fingerprints can be captured by live-scan fingerprint scanners or offline fingerprint capture techniques (inked fingerprint).

2.0 Latent Fingerprint

Latent finger prints are inadvertent impressions left by fingers on surfaces of objects. Latent fingerprint is special type of fingerprint that is lifted from the surface using chemical processes. Latent fingerprint is desirable for forensics applications such as criminal investigation and forensic detection. They are important evidence and useful for identifying criminals. Fingerprint identification is one of the most well-known and publicized biometrics because of their uniqueness and consistency over time, fingerprint has been used for identification for over a century, more recently becoming automated due to advancement in computing capabilities. Fingerprint identification is popular because of the inherent ease in acquisition, the numerous sources available for collection, and their established used and collection by law enforcement.[1].

Fi 2: Sample Latent Fingerprint Images



The main difficulties in latent fingerprint matching are unclear ridge structure, small finger area, and large non-linear distortion while rolled fingerprint are of larger size and contain more minutiae. Latent fingerprint identification is of critical importance to law enforcement agencies in identifying suspects. While tremendous progress has been made in plain and rolled fingerprint matching, latent fingerprint matching continues to be a difficult problem. We will propose a system for matching latent fingerprints to rolled fingerprints that is needed in forensics applications. The experimental results indicate that singularity, ridge quality map, and ridge flow map are the most effective features in improving the matching accuracy. The matching module consists of minutiae matching, orientation field matching. Although tremendous progress has been made in developing automated fingerprint identification Systems (AFIS), most of these systems work well only in scenarios where the matching is performed between rolled or plain fingerprint images.

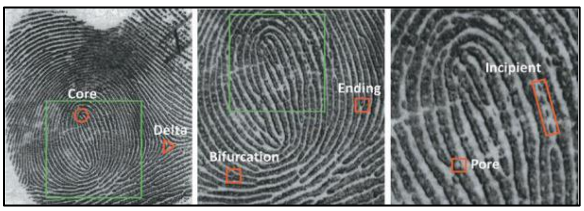
3.0 Approach: Methods and Model Used

A fingerprint usually appears as a series of dark lines that represent the high, peaking portion of the friction ridge skin, while the valleys between these ridge appears as white space and are the low, shallow portion of the friction ridge skin. Fingerprint identification is based primarily on the minutiae, or the location and direction of the ridge ending and bifurcation along a ridge path. The images below present examples of fingerprint features:

- Two types of minutia and
- Examples of other detailed characteristics sometimes used during the automatic classification and minutiae extraction processes.

AFIS technology exploits some of these fingerprint features. Fraction ridges do not always flow continuously throughout a pattern and often result in specific characteristics such as ending ridges, dividing ridges and dots, or other information. An AFIS is designed to interpret the flow of the overall ridges to assign a fingerprint classification and then extract the minutiae detail-a subset of the total amount of information available yet enough information to effectively search a search a large repository of fingerprints.

Fig 3: Feature Extraction Showing Feature Levels in a Fingerprint.



Note that the second and third images are magnified versions of the fingerprint regions indicated by green boxes in the corresponding preceding images.

The fundamental steps used in model are described below:

Step 1: Load

The first stage of any vision system is load. After the image has been load, various step of processing can be applied to perform different tasks. Without image load, the processing on image is not possible.

Step 2: Histogram Equalization

Histogram equalization is a step in image processing of contrast adjustment using the image's histogram. Histogram equalization is to develop the pixel value dispensation of an image so as to increase the perceptional information. The real histogram of a fingerprint image has the bimodal type, the histogram after the histogram equalization has all the range from 0 to 255 and the visualization construct is enhanced.

Step 3: Fingerprint Enhancement by Fourier Transform

Fourier transform is an important step which is used to decompose an image into its sine and cosine tool. It is used in image analysis, image filtering, and image reconstruction. In fingerprint enhancement by Fourier transform we divide the image into small processing blocks (32 by 32 pixels) and show the Fourier transform according to:

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) \times \exp\left\{-j2\pi \times \left(\frac{ux}{M} + \frac{vy}{N}\right)\right\} \quad (1)$$

For u = 0, 1, 2... 31 and v = 0, 1, 2... 31.

In order to enhance a specific block by its dominant frequencies, we multiply the FFT of the block by its magnitude a set of times. Where the magnitude of the original FFT = abs(F(u,v)) = |F(u,v)|.

Get the enhanced block according to

$$g(x,y) = F^{-1}\left\{F(u,v) \times |F(u,v)|^{K}\right\} \quad (2),$$

Where F-1(F(u,v)) is done by:

$$f(x,y) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} F(u,v) \times \exp\left\{j2\pi \times \left(\frac{ux}{M} + \frac{vy}{N}\right)\right\} \quad (3)$$

for x = 0, 1, 2, ..., 31 and y = 0, 1, 2, ..., 31.

The k in formula (2) is an experimentally resolved constant, which we choose k=0.45 to calculate. While having a higher "k" improves the appearance of the ridges, filling up small holes in ridges, having too high a "k" can result in false joining of ridges.

Step 4: Fingerprint Binarization

Binarization is an image enhancement technique. Fingerprint Image Binarization is to transform the 8-bit Gray fingerprint image to a 1-bit image with 0-value for ridges and 1-value for furrows. After the operation, ridges in the fingerprint are highlighted with black color while furrows are white. A locally adaptive binarization method is presented to binarize the fingerprint image.

Step 5: Block Direction Estimation

Estimate the block direction for each block of the fingerprint image with WxW in size, where W is 16 pixels by default. The algorithm is:

1. Evaluate the gradient values along x-direction and y-direction for each pixel of the block. Two Sobel filters are used to complete the task.
2. To get the Least Square approximation of the block direction, use the following formula:

tg2ß = 2 (gx*gy)/(gx2-gy2) for all the pixels in each block.

The formula is simple to understand by regarding gradient values along x-direction and y-direction as cosine value and sine value. So the tangent value of the block direction is calculated nearly the same as the way illustrated by the following formula.

tg2θ = 2sinθ cosθ / (cos2θ -sin2θ)

The direction map is shown in the following diagram. We assume there is only one fingerprint in each image.

Step 6: ROI Extraction by Morphological Operation

Region of interest is a part of an image that we want to filter or act some operation on. Two Morphological operations called „OPEN‟ and „CLOSE‟ are selected. The „OPEN‟ operation can develop images and remove peaks launched by background noise. The „CLOSE‟ operation can shrink images and eliminate small cavities.

Step 7: Fingerprint ridge thinning

Thinning is a morphological operation that is used to delete the selected foreground pixels from binary images somewhat like opening.

The thinned ridge map is then filtered by other three Morphological operations to remove some H breaks, isolated points and spikes.

Step 8: Minutiae marking

After the fingerprint ridge thinning, marking minutia points is simple. But it is still not a trivial task as most literatures declared because at least one special case evokes my caution during the minutia marking stage. In general, for each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch. If the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending.

Step 9: Minutiae match

Given two set of minutia of two fingerprint images, the minutia match algorithm consider whether the two minutia sets are from the same finger or not.

An alignment-based match algorithm partially derived from the is used in my project. It has two stages: one is alignment stage and the second is match stage.

1. **Alignment stage**:

Given two fingerprint images to be matched, choose any one minutia from each image; calculate the similarity of the two ridges associated with the two referenced minutia points.

If the similarity is larger than a threshold, transform each set of minutia to a new coordination system whose origin is at the referenced point and whose x-axis is coincident with the direction of the referenced point.

2. **Match stage**:

After we get two set of transformed minutia points, we use the elastic match algorithm to count the matched minutia pairs by assuming two minutia having nearly the same position and direction are identical.

Step 10: Match stage

The matching algorithm for the place minutia patterns require to be elastic since the strict match requiring that all parameters (x, y, □) are the same for two identical minutiae is intolerable because of slight deformations and inexact quantization of minutia. This approach to flexible match minutia is obtained by placing a bounding box around each template minutia. If the minutia to be matched is within the rectangle box and the direction discrepancy between them is very small, then the two minutiae are considering as a matched minutia pair. Each minutia in the template image either has no matched minutia or has only one corresponding minutia. The last match ratio for two fingerprints is the number of total matched pair over the number of minutia of the template fingerprint. The score is 100*ratio and ranges from 0 to 100. If the score is greater than a pre-specified threshold, the two fingerprints are from the same finger.

4.0 Evaluation Indexes for Fingerprint Recognition

Two indexes are well accepted to resolve the performance of a fingerprint recognition system: one is false rejection rate and the other is FAR false acceptance rate. For an image database, each sample is matched oppose the remaining samples of the same finger to calculate the False Rejection Rate.

If the matching g opposite h is execute, the symmetric one (i.e., h opposite g) is not performed to avoid correlation.

All the scores for such matches are collected into a series of right Score. Also the first sample of each finger in the database is matched opposite the first sample of the remaining fingers to calculate the False Acceptance Rate. If the matching g opposite h is performed, the symmetric one (i.e., h against g) is not executed to avoid correlation.

All the scores from such matches are collected into a series of Incorrect Score.

5.0 Experimentation Results

A fingerprint database from the FVC2000 (Fingerprint Verification Competition 2000) is used to test the experiment display. My program tests all the images without any fine-tuning for the database. The experiments display my program can dissimilar imposturous minutia pairs from genuine minutia pairs in a certain confidence level. Moreover, good experiment designs can surely improve the accuracy as declared by. More studies on good designs of training and testing are expected to improve the result. While, the elastic match algorithm has large calculation complexity and is vulnerable to spurious minutia.

6.0 Conclusion and Future Work

Latent to latent fingerprint is an important research problem that requires comprehensive research. We present a latent fingerprint database that is made accessible to the community for further research. We also design an efficient and highly accurate automatic latent to full-print matching system which should be able to provide a quantitative estimate of the probability that two fingerprints being compared belong to same finger.

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