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Improve Fingerprint Recognition Using Both Minutiae Based and Pattern Based Method

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ABSTRACT

Fingerprint recognition is one of the biometric techniques that are used for identification purpose. A number of recognition methods have been used to perform fingerprint matching. The Straightforward matching between the fingerprint pattern to be identified and many already known patterns would not serve well due to its high sensitivity to errors. This paper presents a combination of pattern based and minutiae based method. Here first core point, delta points and minutiae features are found and based on that matching is to be done. Here poor quality of fingerprint images are also enhanced using wiener low pass filter.

Key words: Fingerprint, Pattern, Minutiae features, Low pass filter.

INTRODUCTION

The fingerprints have been used as a mean for identifying individual for a long time because the fingerprints are unique and stay unchanged throughout an individual life time. The chance of two people—even identical twins—having the same fingerprint is probably less than one in a billion. Fingerprint comparison is the most widely used method of biometric authentication and the most cost effective. Currently there are about 200 million FBI cards (10 fingerprints per cards) stored in cabinets that would fill an area of one acre.

The manual effort of identifying and maintaining such a system is very cumbersome, time consuming and expensive as the number of finger print records grows at a rate from 30 to 50 thousands cards per day[1].

What is a fingerprint?

A fingerprint is the feature pattern of one finger (Figure 1). It is an impression of the friction ridges and furrows on all parts of a finger. These ridges and furrows present good similarities in each small local window, like parallelism and average width[2]

There are two basic methods of fingerprint recognition: -

(i) Minutiae based method
(ii) Pattern based method.

Minutiae based method

Most of the finger-scan technologies are based on Minutiae. Minutia-based techniques

represent the fingerprint by its local features, like terminations and bifurcations. This approach has been intensively studied, also is the backbone of the current available fingerprint recognition products. Figure 2 shows the termination and bifurcation points.

Pattern based method

Pattern based algorithms compare the basic fingerprint patterns (arch, whorl, and loop) between a previously stored template and a candidate fingerprint. This requires that the images be aligned in the same orientation. To do this, the algorithm finds a central point in the fingerprint image and centers on that.

Fingerprint classification:

The analysis of fingerprints for matching purposes generally requires the comparison of several features of the print pattern. These include patterns, which are aggregate characteristics of ridges, and minutia points, which are unique features found within the patterns. Individuals generally have a mixture of pattern types on their fingertips, with some correlation between the left and right hands. While the loop pattern is the most common pattern, classification of individuals by assigning a pattern type to each of the ten fingers in an ordered fashion, serves as a first line of differentiation, however, no such classification is likely to be unique.[3] The three basic fingerprint classifications are the loop, arch, and whorl. See figure 4

Loop

A loop is a pattern where the ridges enter from one side of a finger, form a curve, and tend to exit from the same side they enter. A single delta type divergence must be present in front of the looping ridges. There are two types of loops: Right loop and Left loop.

Left Loop

Circular pattern that is fingerprint lines access from one direction then back from the same direction after a rotation around. To the left is Left Loop. There is a core and a delta at the lower left.

Right Loop

To the right is Right Loop. There is a Core and a delta at the lower right.

Arch

An arch is a pattern where the ridges enter from one side of the finger, rise in the center forming an arc, and then exit the other side of the finger. There are two types of Arch: Plain Arch and Tented Arch.

Plain Arch

Ridges enter wave or rise and exit smoothly.

Tented Arch

Ridges rise in the center, thrust upward to give an appearance similar to tent. Inside angle is smaller than 90 degrees

Whorl

At least two delta type divergences are present with looping ridges in front of each. There are four types of Whorl: Plain Whorl and Double Loop

Fig. 1: Fingerprint image on a sensor

Fig. 2: Ridge Ending and Ridge Bifurcation

Plain Whorl

One or more ridges form a complete revolution around the center with two deltas.

Double Loop

Two separate loops are present which sometimes surround each other.

Fig. 3: Core and Delta point

Proposed work

There are two basic steps: Pre-processing and Post-processing.

Pre-processing consist of

Fingerprint Image Reading

In this step, the fingerprint image is loaded by using the Matlab built-in function

RGB to Gray Image

Raw data of fingerprint image obtained is in the RGB format. The fingerprint image in the RGB format is then changed into gray scale image so that image processing can be executed on the image.

Image Enhancement

Sometimes, the image obtained does not have good quality and thus the purpose of enhancement is to process the image obtained so

Fig. 4: Patterns of fingerprint

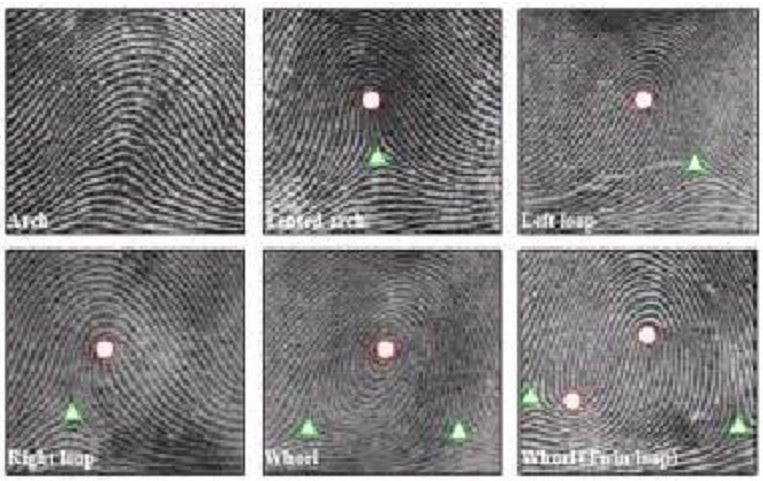

Fig. 5: Example of fingerprint patterns

as to make it clearer by improving perception or interpretability and hence the accuracy of matching will be increased. By enhancing the image, the quality of image can be upgraded and thus the contrast between ridges and valleys can be increased. Here histogram equalization is done followed by wiener low pass filter is used.

Histogram Equalization

To increase the contrast of the captured image histogram equalization is necessary. The histogram of a digital image with gray levels in the range (0, L-1) is a discrete function defined by

P (rk) = nk/n

Where, Rk- Kth gray level

Nk- no. of pixels

Weiner low pass filter

To smooth the high frequency regions of the print low pass filtering is necessary. For this purpose *Weiner Lowpass Filtering* is used.

Binarization

Image binarization is one of the image pre-processing stage with the purpose of converting a gray scale image into a binary image. Gray scale image has 256 gray levels (0-255) while a binary image consists of 0-1 (black and white) where 0 is for ridge and 1 is for furrow. Binarization is an important process as binary image is needed for the thinning process instead of gray scale image

$$I(x,y) = \begin{cases} 1 & If(I(x,y) \geq t, \\ 0 & otherwise \end{cases}$$

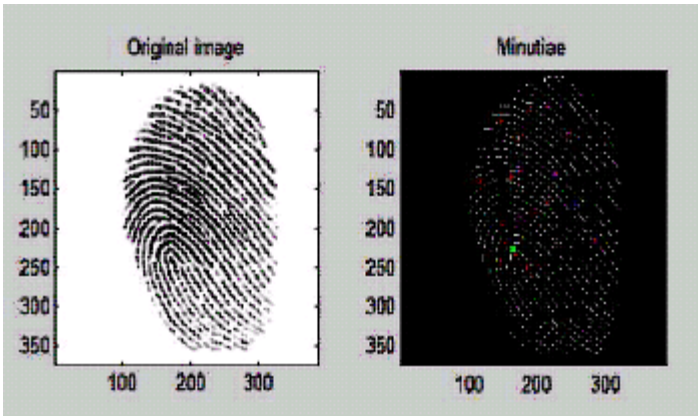

Fig. 6: Original image and Features extracted

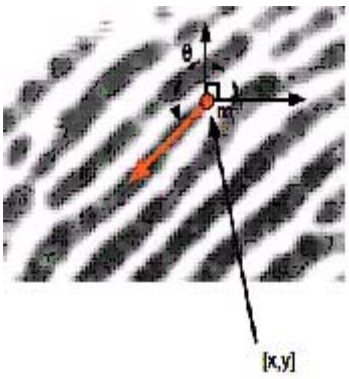

Fig. 7: Minutiae triplet structure representation.

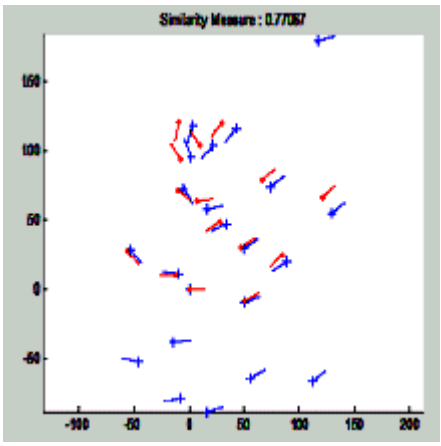

Fig. 8: Similarity score

Post-processing involves:

Thinning

It is the process done on binary image by reducing all lines of fingerprint into thickness of one single pixel. After thinning process, the fingerprint image is in single pixel width where each ridge is thinned to center pixel and there are no discontinuities. This is done using the MATLAB's built in morphological thinning function.

bwmorph(binaryImage,'thin',Inf)

Termination and Bifurcation Extraction

Then the thinned binarized image has each pixel to be analyzed in order to find the minutiae location. This is done by having a 3x3 window is traversed in anticlockwise direction to find a crossing number(cn).

$$cn=\frac{1}{2}\sum i=1 \ldots 8 \left|val(p_{(i \bmod 8)}) - val(p_{i-1})\right|$$

if cn=3 then that point is a bifurcation, if cn=1 then mark it as termination, if cn=5 it is a core point and if cn>5 it is a delta point.

Removal of false minutiae

Invalid end points, branch points and pores are removed from the templates by comparing it with the original image. Thus reducing the error rate.

Fingerprint matching:

Similarity score:

We produce geometric constraints for the discovery of minutiae matching pairs, including geometric distance:

$$distr(m_{Ai}, m_{Bj}) = \sqrt{(x_{Ai} - x_{Bj})^2 + (y_{Ai} - y_{Bj})^2} < r\delta$$

Or to account for scale difference (i.e. if we are comparing images collected from different resolution scanners

$$distr(m_{Ai}, m_{Bj}) = \sqrt{(x_{Ai} - k_x x_{Bj})^2 + (y_{Ai} - k_y y_{Bj})^2} < r\delta$$

and minutiae angle difference

$$dist\theta(m_{Ai}, m_{Bj}) = \min(|\theta_{Ai} - \theta_{Bj}|, 360^\circ - |\theta_{Ai} - \theta_{Bj}|) < r\theta$$

The geometric tolerance **rä** is in place to account for distortion that may occur, whereas is the tolerance for angular differences that may arise due to orientation estimations from the ridge orientation images, m_{Ai}, m_{Bi} ,are the minutiae pairs.

Once genuine minutiae pairs are produced, a metric of similarity, usually called the similarity score, can then be calculated. The similarity score must accurately describe how similar two fingerprints are, taking into account all of the relevant information obtained from earlier stages, such as number of genuine minutiae pairs and how similar each pair is. One similarity score given in Liang & Asano (2006) is defined as

$$sim(A,B) = \frac{n_{match}^2}{n_A . n_B}$$

where nmatch is the number of matching minutiae pairs, and n_A, n_B are the number of minutiae in the overlapped regions of the template and test fingerprints following registration.

CONCLUSION

In this paper, we have proposed a reliable method for feature extraction from fingerprint images. The main contribution of the of this paper are (i) extra types of pattern (ii) finding minutiae points(iii) fingerprint verification (iv) fingerprint matching. In the pattern based matching the core point and delta points are detected. But problem occurs when only partial print is available. So core point as well as delta could not be found so matching is not possible. Whereas in minutiae based only minutia features are to be extracted and it could be found also in partial prints and using these features test image is matched with those stored in the template.

Future work

Thus the combination of minutiae based and pattern based could be used to obtain accurate result when only partial print is available. But combining these two methods is time consuming as larger templates are to be stored. Thus work can be done to make the technique time efficient. As well as more work can be done to execute the matching procedure faster.

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