Fingerprint and Minutiae Points Technique

Karun Verma and Ishdeep Singla

Abstract This paper will extensively dictate the whole basic details of fingerprint and its techniques. Moreover one of the most important and widely used techniques that is minutiae point extraction technique is also covered in detail. The minutiae points are extracted with the help of cross-number algorithm. Cross-number algorithm also helps for the rejection of false minutiae point's extraction

Keywords Biometrics · Fingerprint · Minutiae points

1 Introduction

In an increasingly digital world, the control over entry of authorized person has become a vital thing. From the personal computer to National security, there is big use of identity checking that is Authentication. And biometrics provide automated access to the security systems. It's always better to use some automated methods instead of remembering and filling passwords. In biometrics, fingerprint technology is widely used technology, using this technology we need not to carry any identity card. Finger works as identity card, meaning there are no tension of forgetting and losing identity cards [1].

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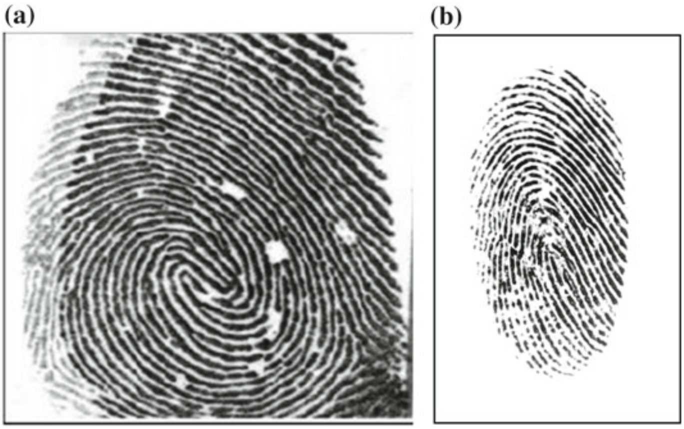

Fig. 1 Fingerprint images: **a** inked fingerprint and **b** live-scan fingerprint [3]

2 What is Fingerprint?

Fingerprint is the graphical flow-like ridges. It is present on each and every finger of every human's fingers as shown in Fig. 1. Ridges are embedded on all fingers from the very first day of our birth and do not change throughout the life. It may only change if a serious accident such as bruises and cuts or surgery on the fingertips occurs. This property makes fingerprints a very attractive biometric identifier and point of research. Basically, there are two resources for getting fingerprint pattern [2]:

(i) Scanning an inked impression of a finger is shown in Fig. 1a.
(ii) Using a live-scan fingerprint scanner shown in Fig. 1b.

In Fig. 1, dark lines are called ridges and the white area that exists between the ridges are called valley or furrow.

3 Fingerprint Features

Fingerprint features are those attributes of a fingerprint that may be useful either to classify or to uniquely identify the fingerprint. There are two main types of features, namely, the local features and the global features. Figure 2a shows the local features and Fig. 2b shows the global features.

3.1 Global Features

The fingerprint global features are identified by means of the local orientation of the fingerprint ridges, that is, the Orientation Field Curves (OFCs). As shown in Fig. 2b the core and the delta are the features which have been located in central position of

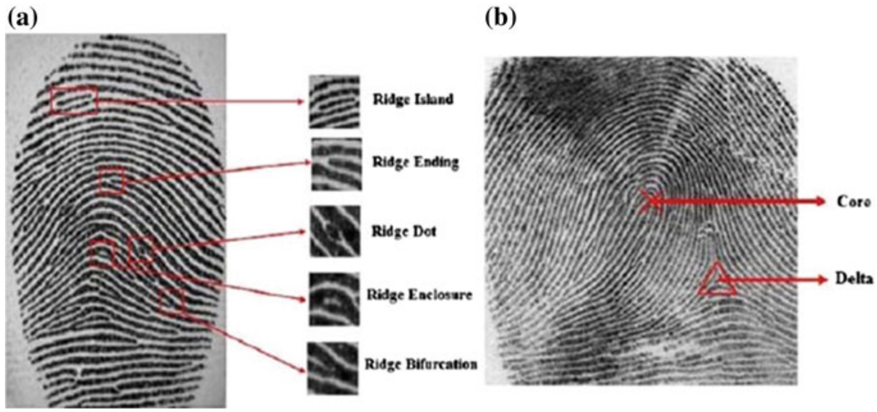

Fig. 2 **a** Local Features: Minutiae; **b** global features: core and delta [3]

fingerprint. A Core is the area around the center of the fingerprint loop and a Delta is the area where the fingerprint ridges tend to triangulate. Due to their unique property, both plays an important role to compare one fingerprint with other fingerprints [4].

3.2 Local Features

The fingerprint local features are those attributes that give the minutiae details about the fingerprint pattern. Minutiae further provide various ways that the ridges can be discontinuous. A ridge can suddenly end (termination), or can divide into two ridges (bifurcation) as shown in Fig. 2a. There are 40–100 minutiae point in a good quality image [8]. And in a fingerprint image of 300 × 300 pixels the distance between two fingerprints vary between 1-113 pixels. With these features and numerical figures, local features have become more suitable to compare fingerprints [4]. There are many methods like cross number are available to extract the minutiae points.

4 Fingerprint Classification

It is obvious that with the increase database size complexity and automatic comparison time will also increase. So to reduce the search time and computational complexity, there is a need to classify fingerprint in a precise and consistent manner which will help to reduce search time with less number of comparisons. According to Galton–Henry classification (Galton, 1892 and Henry, 1900) classification, we classify fingerprint images into five major classes: plain arch, tented arch, left-loop, right-loop, and whorl (a plain and twin loop, respectively).

Arch: In whole fingerprint arch covers only 5 % of the portion. These consist of ridges that run major in horizontal manner can say from left to right as shown in Fig. 3. There are two types of arches: plain arches and tented arches. Generally, plain arch has no singular points. While tented arch have one core and one delta.

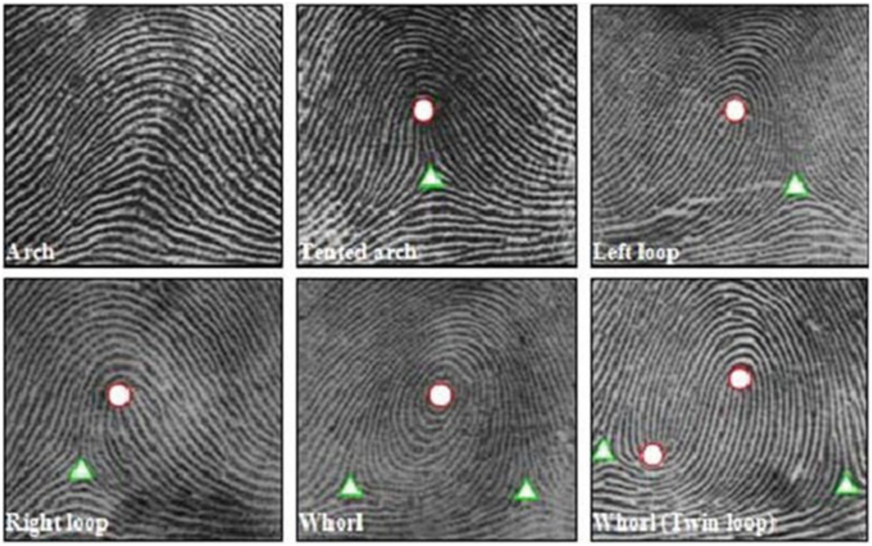

Fig. 3 Fingerprint classes [5]

Loop: Loops cover 60–70 % of whole fingerprint pattern. As the name suggests set of the ridges enters on either side of the fingerprint, bends, touches, or crosses the line running from the delta to the core and run back in same direction of the side where the ridge or ridges entered as shown in Fig. 3. Each loop pattern has one delta and one core. There can be left loop or right loop.

Whorl: 25–35 % of fingerprint pattern is covered by whorl. In a whorl, more than one ridges moves through at least one circuit. A whorl pattern always consists of two or more deltas. There are two types of whorl plain whorl and double whorl. A plain whorl is the pattern which consists of some ridges which make or partially make a complete circuit with two deltas. Double loop whorl consists of two separate and distinct loops.

5 Fingerprint Matching Techniques

There a lot of techniques for matching a fingerprint. There are three most popular methods for matching fingerprints [2] described below.

5.1 Correlation-based Matching

In this method one fingerprint image is superimposed on other. The correlation between corresponding pixels is computed for different alignments and on the basis of these correlations and computations decision is made.

5.2 Pattern-based (or Image-based) Matching

In pattern-based algorithms, the basic fingerprint patterns (arch, whorl, and loop) are used to compare fingerprints, between a previously stored template and a candidate fingerprint. This requires that the images are aligned in the same orientation. To do this, the algorithm finds a central point in the fingerprint image and centers on that. In a pattern-based algorithm, the template contains the type, size, and orientation of patterns within the aligned fingerprint image. The candidate fingerprint image is graphically compared with the template to determine the degree to which they match.

5.3 Minutiae-based Matching

This is the most popular and widely used technique, being the basis of the fingerprint comparison made by fingerprint examiners. Minutiae are extracted from the two fingerprints and stored as sets of points in the two-dimensional plane. Minutiae-based matching essentially consists of finding the alignment between the template and the input minutiae sets that result in the maximum number of minutiae pairings. In this thesis we have implemented a minutiae-based matching technique. This approach has been intensively studied, also is the backbone of the current available fingerprint identification products.

6 Minutiae Extraction

Minutiae points matching is the best approach for the matching of fingerprints. The work of minutiae extraction includes some important steps that are Ridge Thinning, Minutiae Marking, False Minutiae Removal, and Minutiae Representation.

6.1 Ridge Thinning

The main aim of this step is to convert the redundant pixels of ridge into one pixel wide. This will be very helpful in finding minutiae points and to implement minutiae point algorithm. In Matlab there has been one very popular morphological thinning function to perform this task.

bwmorph(binaryImage,'thin',Inf)

The thinned image is then filtered, again using MATLAB's three morphological functions to remove some H breaks, isolated points, and spikes (see Fig. 4).

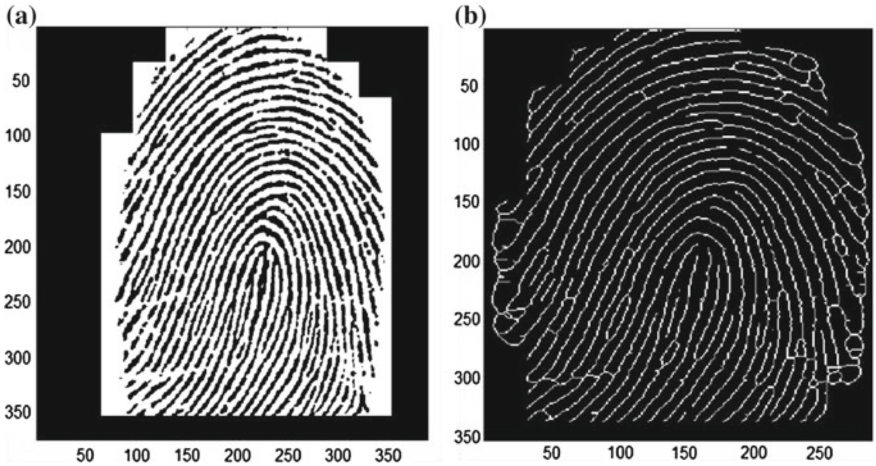

Fig. 4 **a** Binarize image; **b** Thinning image

bwmorph(binaryImage,'hbreak',k) → For H breaks
bwmorph(binaryImage,'clean',k) → For isolated points
bwmorph(binaryImage,'spur',k) → Spikes

6.2 Minutiae Marking

The name of this algorithm is crossing number (CN). It is implemented thinned image. Iteratively a 3 × 3 pixels wide picture is selected from thinned image then check that if the central pixel is a ridge branch and the central pixel is 1 and has exactly three neighbors of 1's, then its *bifurcation* (see Fig. 5).

If there one central 1 with exactly one 1in its neighbourhood, then its a *ridge ending* (see Fig. 6).

Fig. 5 Ridge bifurcation

0	1	0
0	1	0
1	0	1

Fig. 6 Ridge termination

0	0	0
0	1	0
0	0	1

6.3 False Minutiae Removal

As fingerprint sample maybe taken from ink impression (paper, thing) or it may be taken by using fingerprint scanner. But in case of ink impression the fingerprint quality may suffer. The quality of ink impression fingerprint image may be low which creates false minutiae points. So in most of the cases it need to be eliminated. To remove false minutiae points first calculate the inter ridge distance D (say) which is the average distance between two neighboring ridges. For this scan each row calculate the inter ridge distance using the formula [6]:

$$\text{Inter ridge distance} = \frac{\text{sum all the pixels in the row whose value is one}}{\text{row length}}$$

Calculate an average of all the inter ridge distance D. A MATLAB morphological operation 'BWLABEL' is helpful in this task. There have been seven different cases studied of false minutiae point's patterns. Follow the steps to remove these seven erogenous patterns (see Fig. 7) [6, 7].

- If d (bifurcation, termination) $< D$ and the two minutia are in the same ridge then remove both of them (case $m1$).
- If d (bifurcation, bifurcation) $< D$ and the two minutia are in the same ridge then remove both of them (cases $m2$, $m3$).

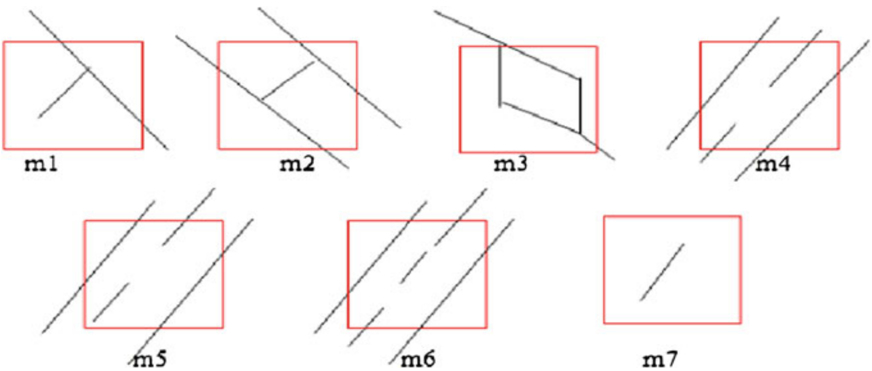

Fig. 7 False minutia structures

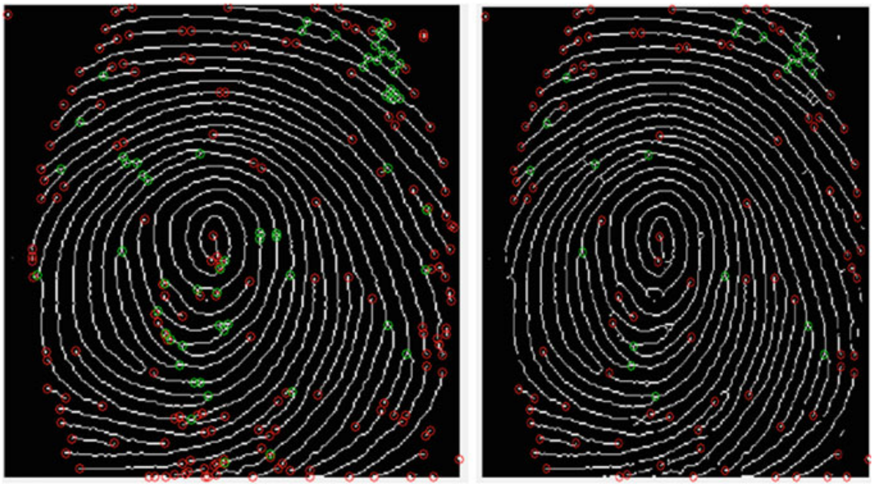

Fig. 8 Remove spurious minutiae

- If d (termination, termination) $\approx D$ and the their directions are coincident with a small angle variation and no any other termination is located between the two terminations then remove both of them (cases $m4$, $m5$, $m6$).
- If d (termination, termination) $< D$ and the two minutia are in the same ridge then remove both of them (case $m7$) (Fig. 8).

7 Conclusion

Fingerprint technique is good biometric technique for identification. Most of the time fingerprint is not of good quality. Due to low quality image false minutiae points get increases. But low quality image needs to preprocessed. Preprocessing to increase contrast, and reduce different types of noises. When some background region is included in the segmented regions of interest, noisy pixels also generate many spurious minutiae because these noisy pixels are also enhanced during preprocessing and enhancement steps. There is a scope of further improvement in terms of efficiency and accuracy, which can be achieved by improving the image enhancement techniques or by improving the hardware to capture the image. So that the input image to the thinning stage could be made, better this could improve the future stages and the outcome.

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