# Fingerprint Image Analysis Using Statistic and Computational Geometric Techniques

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## Abstract

*In this paper, we have presented a Fingerprint Recognition System which combines both the features extraction by applying a statistical and geometry approach. First, the core point (CP) of the input fingerprint is detected. Next, we find again fingerprint features such as minutiae point location. Each furrow pattern is extracted and measured relative distance from core point in horizontally and vertically based on the fingerprint image's core point. These above mentioned features are stored in different databases. And then the input fingerprint features are compared with above pre-defined database and decision will be made by voting system. We conducted evaluations on the FVC-2004 datasets and have summarized the results in the conclusion section.*

*Keywords- Fingerprint recognition; Geometry; Voting system.*

## 1. Introduction

Fingerprint is one of the most widely used biometric techniques in the world today. It is a rapidly evolving technology that has been widely used in forensics, such as criminal identification and prison security, and has the potential to be widely adopted in a very broad range of civilian applications. Using fingerprint to make a personal identification has the following characteristics:
(1) Universality, which means that every person should have the characteristic,
(2) Uniqueness, which indicates that no two persons should be the same in terms of the characteristic,
(3) Permanence, which means that the characteristic should be invariant with time, and
(4)Collectability, which indicates that the characteristic can be measured quantitatively.

The primary purpose of fingerprint identification is for crime prevention. Later, private and security purposes of this system are principal applications of biometric recognition such as cellular phone, notebooks and other mobile device. National ID card and attendance cards are substituted with automatic fingerprint recognition system. But the fingerprint recognition system still faces with defect in accuracy rate. The primary objectives of the proposed system will perform more accurate in rate.

There are many different proposed systems for fingerprint recognition based on image, neural and fuzzy approach.

The proposed algorithm is practical for fingerprint recognition. The basic idea is to extract by the number of end points and bifurcation points. A more logical approach is to extract the coordinate of distinct feature points and angle of their points according to their furrow pattern of fingerprint. This system illustrates the processing by considering elementary geometric terms and statistical computation. This system checks all of the features for input fingerprint image. Finally, the input fingerprint image features and fingerprint features in database are matched and the output result is given out.

The next section describes the related works. Section 3 describes the IFR system in detail. Section 4 presents statistical and geometry calculations of system. Fingerprint classification by voting system is described in section 5. Experimental results of this paper are presented in section 6. Finally, we conclude paper with future work.

## 2. Related works

In biometric, there are various matching methods for effectiveness of recognition results. B.C Seow proposed that [7] verification system may be applied directly on grey level image. M.V. karki [2] proposed minutiae count and direct angle difference between minutiae point pair. Fingerprint verification using Gabor Co-occurrence features has been proposed by S.Arivazhagan. For fingerprint verification, Gabor Walet Transform (GWT) algorithm [4] is used in this approach. Euclidean distance between fingers codes is considered to match. Aliaa A.A. Youssif has proposed a fingerprint recognition system. Hybrid method [5] based on a minutiae-based and correlation based is used in this system. In conclusion, the author suggests that hybrid method can perform better than the individual method. J.Yang and J.W.Shin [3] showed a global minutiae and invariant moments that used the feature extraction and matching. These

features vector contained radial distance, radial angle, minutiae direction and minutiae type. According to F.P.S Falguers, A.N. Marana and J.R.FalFalguera represented the fusion of a minutiae-based and a ridge-based fingerprint recognition method [1]. The objectives of the paper are to overcome the weakness and improve the accuracy rate. Y.Thein [8] proposed new MVM system which outputted the vocal sound of each word by mixing the basic character sound with extended vowel sound.

## 3. Proposed system

We use the statistic and geometric features of a fingerprint. The combined features are extracted from the skeletonized fingerprint. The combined feature, introduced in Section 4, is defined for every two minutiae. In this paper, we introduce a new

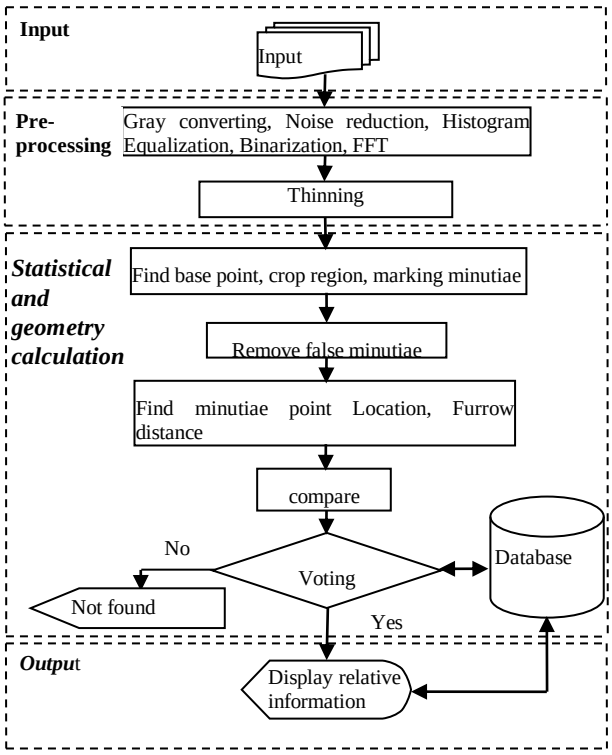


Figure 1.Flow diagram of proposed system

classification named voting method. Figure 1 shows the proposed recognition system.

### 3.1. Preprocessing

The performance of feature extraction for image depends on the quality of input image. To obtain the higher accuracy performance, the input image is made by enhancement technique. In our system, five methods are implemented for image enhancement.

- Gray scale conversion
- Noise reduction
- Histogram equalization
- Binarization
- Fourier transform

### 3.2. Thinning

Thinning is to eliminate all the ridges in a fingerprint to be one pixel thick. The requirements of a good thinning algorithm with respect to a fingerprint are

a) The thinned fingerprint image obtained should be of single pixel width with no discontinuities.
b) Each ridge should be thinned to its centre pixel.
c) Noise and singular pixels should be eliminated.
d) No further removal of pixels should be possible after completion of thinning process.

Figure 2.Before and after image enhancement

## 4. Statistical and geometry calculation

The statistical approach is searching for the statistical characteristic of various fingerprints. These characteristics could be number of loops**,** end points**,** bifurcation points, etc. The geometry information consists of furrow distance, coordinates and angles, etc.

### 4.1. Crop region, base line and base point

Crop region is defined as the interest region (w x w) around base point of input fingerprint image. In this system, the interest region has been considered on the number of same pixels around the base point.

The maximum curvature of the concave ridges is defined as the base line and base point. The base line is horizontal line across base point. In addition, the base point is used to align input fingerprint and enrollment fingerprint.

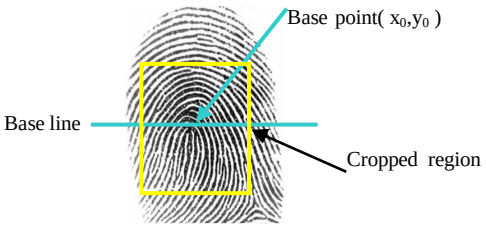


Figure 3.Base line,base point and cropped region

### 4.2. Minutiae marking

After the fingerprint ridge thinning, marking minutia points is the next important step. As the

number of minutiae detected is more the probability of accurate result increases. The concept of Crossing Number (CN) is widely used for extracting the minutiae. Rutovitz's definition of crossing number for a pixel P is given by (1)

$$C_n(p) = (1/2)\sum_{i=1}^{8} |p_i - p_{i+1}| \quad (1)$$

where $P_i$ is the binary pixel value in the neighborhood of P with $P_i$ = (0 or 1) and $P_1 = P_9$. If $C_n(P) = = 1$ it's a ridge end and if $C_n(P) = = 3$ it's a ridge bifurcation point.

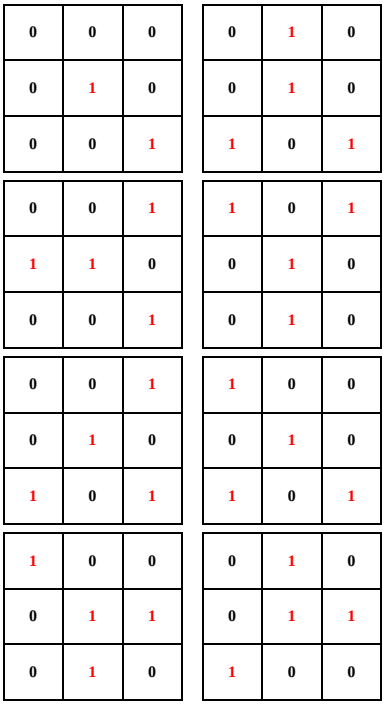


Figure 4.End point and bifurcation point features

For each 3x3 windows, if the central pixel is 1 and $C_n(p)$ = 3 or three one value neighbors correspond to bifurcation. If the central pixel is 1 and $C_n(p)$ = 1 or one one values neighbor correspond to termination point. After applying image enhancement steps, the possible termination and bifurcation features are shown in Figure 3.

### 4.3 Remove specious minutiae

The preprocessing stage does not totally heal the fingerprint image. For example, false ridge breaks due to insufficient amount of ink and ridge cross connections due to over inking are not totally eliminated.

Let d is the average distance between one ridge and its nearest neighbour ridge.

The following conditions are false minutiae features:

- The distance between two bifurcation points is less than d
- The distance between two termination points is less than d
- The distance between one bifurcation point and one termination point less than d

All these points are regarded as spurious minutiae points and then removed these points. The removal technique results confirm high accuracy of the proposed (IFR) system.

### 4.4 Furrow distance

After the base point is located, IFR system calculates the distance between furrow patterns up direction from base point. Each furrow pattern consists of many curves. Among them, there are various distances for a fingerprint image. This distances are expressed as ($u_1$, $u_2$, $u_3$, …. ,$u_n$) that are stored in database.

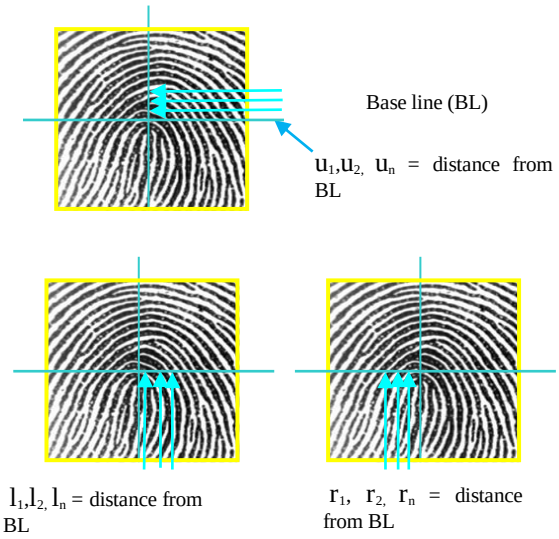


Figure 5. Furrow distance (a) up direction, (b)left direction(c) right direction

## 5. Fingerprint classification by voting system

Fingerprint classification is challenging pattern recognition task that has captured the interest of several research. Therefore it required robust algorithms for accuracy and reliability in fingerprint recognition. The matching of a fingerprint is based on the minutiae features that are extracted in the statistical and geometry information. Each minutia features of a fingerprint image is described as (CODE, $X_i$, $Y_i$, DEG, Furrow Distance…). After completing the decision of parameters for each

fingerprint image, we put them on the properties array to record them. We compared features of each image with User-Defined Database in IFR. For matching the features of each sample, the input fingerprint features and final decision will be made by a voting system. Voting idea is to get the maximum results of all features.

## 6. Experimental results

This performance evaluation has been carried out on FVC2004 of standard database. This database contains four distinct databases (1) DB1_A, (2) DB2_A, (3) DB3_A, (4) DB4_A. Each database consists of 800 fingerprint images (i.e.100 persons, 8 fingerprints per individual). It can be concluded that the result of combination measurement is higher in accuracy rate than individual.

This paper described a simple statistical and geometry recognition method. The objective of the algorithm is to achieve higher accuracy percentage and to produce the related information of input image correctly from database. The total features are count of distinct points, coordinate of their points and angles. The result of experiment indicates accuracy rate not only for each measurement but also for combination of all methods in Table 1.

Table 1. Accuracy rate

| Database | DB1_A | DB2_A | DB3_A | DB4_A |
|---|---|---|---|---|
| End point coordinate | 87% | 86% | 89% | 84% |
| Bifurcation point coordinate | 90% | 89% | 88% | 86% |
| Furrow pattern distance | 89% | 87% | 85% | 83% |
| All information collected | 95% | 97% | 93% | 98% |

## 7. Conclusion

Image quality is directly related to the final performance of automatic fingerprint authentication systems. Good quality fingerprint images need only minor preprocessing and enhancement for accurate feature detection algorithm. But low quality fingerprint images need substantial preprocessing to increase contrast, and reduce different types of noises. In our research, we have cropped the image into smaller portion of size A x A for further processing and features extraction.

Experimental results indicate that, the proposed method is very efficient than the other methods proposed in the literature. Also it will reduce the cost of a fingerprint biometric system, as no additional hardware is required.

Experiment shows that accuracy rate for combination of all measurement performs better than individual methods shown in Figure6. The proposed system can identify the more accurate measurement for feature vectors of accuracy percentage. This method takes less time for recognition of input image. The idea is to express the computation and geometry logic for joining the all different measurement results. But fingerprint recognition system is vulnerable to security aspects. In future work, the non-minutiae based algorithm can be applied. Also, our future work will be paid to improving our algorithm for partial fingerprint.

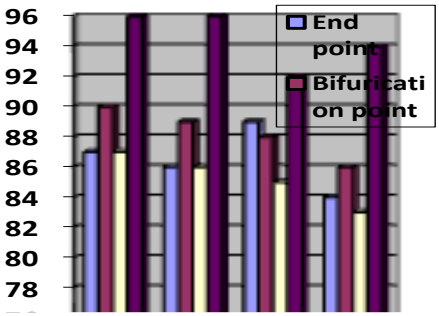


Figure 6. Experimental Result for each database

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