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Spurious Minutia Removal Technique using Euclidean distance approach

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Abstract: ***Fingerprints are the oldest and most widely used form of biometric identification. Everyone is known to have unique, immutable fingerprints. As most Automatic Fingerprint Recognition Systems are based on local ridge features known as minutiae, marking minutiae accurately and rejecting false ones is very important. However, fingerprint images get degraded and corrupted due to variations in skin and impression conditions. Thus, image enhancement techniques are employed prior to minutiae extraction. A critical step in automatic fingerprint matching is to reliably extract minutiae from the input fingerprint images. This paper proposes the classification of false minutiae for better matching results. The fake minutia are rejected on the basis of 3 most common cases.***

Keywords: fingerprint images, spurious minutia, minutiae extraction, ridge endings, ridge bifurcation, fingerprint recognition.

1. Introduction

Biometrics is the science of uniquely recognizing humans based upon one or more intrinsic physical or behavioral features [3]. Fingerprints are the most widely used parameter for personal identification amongst all biometrics. Fingerprint identification is commonly employed in forensic science to aid criminal investigations etc. A fingerprint is a unique pattern of ridges and valleys on the surface of a finger of an individual [8]. A ridge is defined as a single curved segment, and a valley is the region between two adjacent ridges. Minutiae points are of two types: ridge endings and bifurcations [6]. These minutiae points which are used for determining uniqueness of a fingerprint.

The verification process either accepts or rejects the user's identity by matching against an existing fingerprint database [27]. In identification, the identity of the user is established using fingerprints. Since accurate matching of fingerprints depends largely on ridge structures, the quality of the fingerprint image is of critical importance. However, in practice, a fingerprint image may not always be well defined due to elements of noise that corrupt the clarity of the ridge structures.

Ridge features like ridge count, ridge length, ridge curvature direction and ridge type together with minutiae to increase the matching performance [17]. There are a number of instances in the literature [20, 21] where evolutionary algorithms are used for matching minutiae of a fingerprint with that of a database of fingerprint images. The results of all such techniques depend on the quality of the input image. Thus, image enhancement techniques are often employed to reduce the noise and to enhance the definition of ridges against valleys so that no spurious minutiae are identified. In fact , matching latent fingerprints from crime scenes is difficult because of their poor quality and the fingerprint matching accuracy is improved by combining manually marked minutiae with automatically extracted ones [22]. Several methods have been proposed for enhancement of fingerprint images which are based on image normalization and Gabor filtering (Hong's algorithm) [1], Directional Fourier filtering [23], Binarization Method [24], enhancement using directional median filter [25], fingerprint image enhancement using filtering techniques [26], image retrieval based on color histogram and textual features[27] and many others[28-30].

1.1 Proposed Technique

The 3 categories are coded into 3 processes: Process 1, Process 2 and Process 3.

1. Process 1 works for Case M1.
2. Process 2 works for case M2 and M3.
3. Process 3 works for case M4, M5, M6 and M7.

The procedures in removing false minutia have two advantages. One is that the ridge ID is used to distinguish minutia and the seven types of false minutia are strictly defined comparing with those loosely defined by other methods. The second advantage is that the order of removal procedures is well considered to reduce the computation complexity. It surpasses the way adopted by [25] that does not utilize the relations among the false minutia types. For example, the procedure3 solves the m4, m5 and m6 cases in a single check routine. And after procedure

3, the number of false minutia satisfying the m7 case is significantly reduced.

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. Actually all the earlier stages themselves occasionally introduce some artifacts which later lead to spurious minutia [15]. These false minutiae affects the accuracy of matching if they are simply regarded as real minutia. So a selective Euclidean based spurious minutiae removal algorithm is proposed for removing false minutia which is an essential step to keep the fingerprint verification system effective.

Seven types of false minutia are specified in following diagrams:

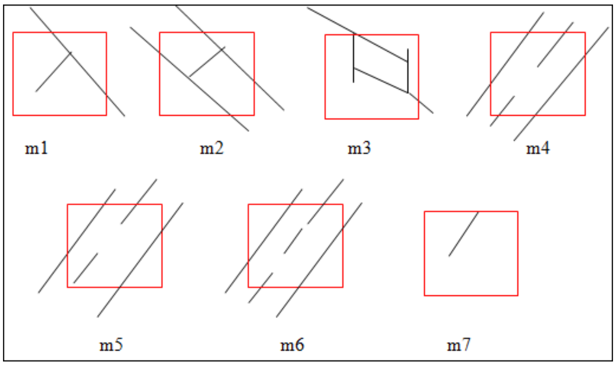


Figure 1.1: False Minutia Structures.

m1 is a spike piercing into a valley.m2 case a spike falsely connects two ridges.m3 has two near bifurcations located in the same ridge.

The two ridge broken points in the m4 case have nearly the same orientation and a short distance.m5 is alike the m4 case with the exception that one part of the broken ridge is so short that another termination is generated.m6 extends the m4 case but with the extra property that a third ridge is found in the middle of the two parts of the broken ridge.m7 has only one short ridge found in the threshold window.

With respect to the survey of various research papers, most commonly found cases of spurious minutiae are m1, m2, m3, m4, m5, m6 and m7. [11, 13] have not false minutia removal by simply assuming the image quality is fairly good. [25] has not a systematic healing method to remove those spurious minutia although it lists all types of false minutia shown in Figure 1 except the m3 case.

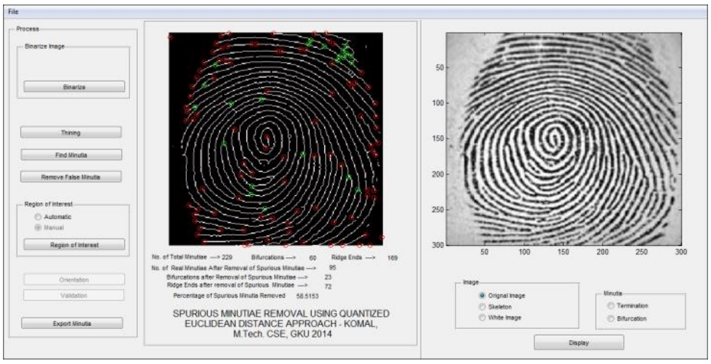


Figure 1.2: Removal of False Minutiae

1.2 PROPOSED PROCEDURE

1. CASE M1 - If the distance between one bifurcation and one termination is less than D and the two minutia are in the same ridge, remove both of them.
2. CASE M2, M3 - If the distance between two bifurcations is less than D and they are in the same ridge, remove the concerned minutia that appear to be two bifurcations.
3. CASE M4, M5, M6, M7 - If two terminations are within a distance D and their directions are coincident with a small angle variation. And they suffice the condition that no any other termination is located between the two terminations. Then the two terminations are regarded as false minutia derived from a broken ridge and are removed.

Where D is the average inter-ridge width representing the average distance between two parallel neighboring ridges.

2. EUCLIDEAN DISTANCE

This technique is use to fairly calculate the distance between two ridge ends, two bifurcations and a ridge end and a bifurcation [4]. The squared length of a vector x = [x1 x2] is the sum of the squares of its coordinates (see triangle OPA in Figure, or triangle OPB – $|OP|^2$ denotes the squared length of x, that is the distance between point O and P); and the squared distance between two vectors x = [x1 x2] and y = [y1 y2] is the sum of squared differences in their coordinates (see triangle PQD in Figure above; $|PQ|^2$ denotes the squared distance between points P and Q).

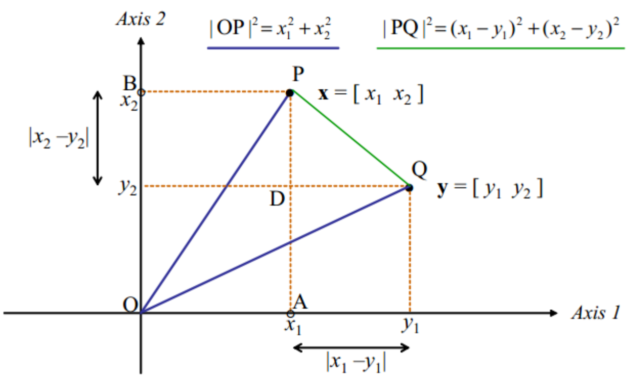


Figure 2.1: Euclidean Distance

To denote the distance between vectors x and y we can use the notation $d_{x,y}$ so that this last result can be written as:

$$d_{\mathbf{x},\mathbf{y}}^2 = (x_1 - y_1)^2 + (x_2 - y_2)^2$$

that is, the distance itself is the square root

$$d_{\mathbf{x},\mathbf{y}} = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2}$$

2.1 Spurious Minutia Removal Technique

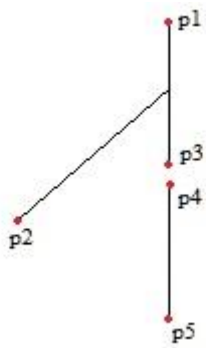


Figure 2.1: Sample Spurious Minutia Representation

Consider the case in figure above, where minutia points p1, p2 and p5 represents a bifurcation. But due to some discrepancy, p3 and p4 appear to be minutia that results the case to be a close combination of a bifurcation (p1, p2 and p3) and a ridge end (p4 and p5).

The process proposed in the algorithm under case M1 analyses the minutia to be spurious.

Let the value of D = 1.3 px (Threshold value)
Coordinates of p3 (253, 69) and p4 (253, 68)

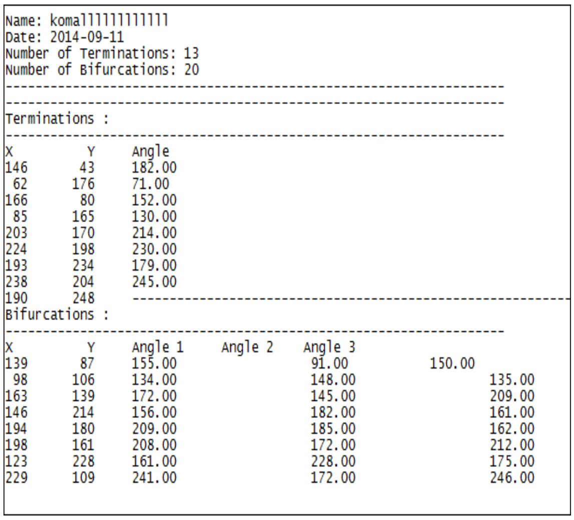
$$d^2 = (253 - 253)^2 + (69 - 68)^2$$
$$d = 1$$

Which is less than D i.e. d<D, thus minutia p3 and p4 are spurious minutia and hence removed.

3. RESULTS

Finger print Name	Minutiae before applying of technique (Real + Spurious)			Minutiae after applying of technique (Only Real)			Percentage of Spurious Minutiae Removed
6	Total	Ridge Ends	Bifurcat-ions	**total**			
	703	269	434	40	17	23	94.3

Table 3.1: Result 1



```
Name: komal111111111111
Date: 2014-09-11
Number of Terminations: 13
Number of Bifurcations: 20
------------------------------------------------------------------
------------------------------------------------------------------
Terminations :
------------------------------------------------------------------
X          Y      Angle
146        43     182.00
 62       176     71.00
166        80     152.00
 85       165     130.00
203       170     214.00
224       198     230.00
193       234     179.00
238       204     245.00
190       248     ----------------------------------------------------------
Bifurcations :
------------------------------------------------------------------
X          Y      Angle 1     Angle 2    Angle 3
139        87     155.00                  91.00            150.00
 98       106     134.00                 148.00                    135.00
163       139     172.00                 145.00                    209.00
146       214     156.00                 182.00                    161.00
194       180     209.00                 185.00                    162.00
198       161     208.00                 172.00                    212.00
123       228     161.00                 228.00                    175.00
229       109     241.00                 172.00                    246.00
```

Figure 3.1: Result 1

CONCLUSION

The proposed spurious minutia removal algorithm works after the detection of minutiae from the available fingerprint image. The combination of multiple methods comes from a wide investigation into research paper. Also some novel changes like Fingerprint Binarization, Fingerprint Thinning and Ridge End marking and finding the bifurcation using Euclidean distance technique are proposed. Categorization and Classification of real vs spurious minutia has proved to be the efficient identification feature. Overall, a set of reliable spurious minutia identification cases are implemented in a selective way. These techniques can then be used to facilitate the further study of the statistics of fingerprint.

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