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A NOVEL FINGERPRINT VERIFICATION USING RIDGE EDGE DETECTION TECHNIQUE

S. Sai Prashanth[1], G.Mukesh[2], Diwakar R.Marur[3] and N.Sukirtharaj[4]

[1, 2, 4] B.Tech Final Year Student,
Department of Electronics and Communication Engineering,
SRM University, Chennai, India
[3] Assistant Professor (S.G),
Department of Electronics and Communication Engineering,
SRM University

ABSTRACT

This paper proposes a method to verify the finger print of any individual based on ridge edge detection. MATLAB is used as the programming tool. The method detects the ridge endings and bifurcations of an individual finger print. The quality of the finger print image is enhanced by pre-processing for better performance. The verification, takes into account of the relative positions and alignment of the ridges. This results in a low false detection rate.

Keywords: *Ridges, Termination points, Bifurcation points, Minutiae, enhancement, suppression, validation.*

INTRODUCTION

Fingerprint is an impression of the ridges, from the surface of the fingertip. Every Fingerprint consists of ridge points called minutiae. These minutiae can be classified into 2 types namely terminations (ridge endings) and bifurcations (ridge splits). It is by comparing the relative positions of these points that fingerprints of different individuals can be identified.

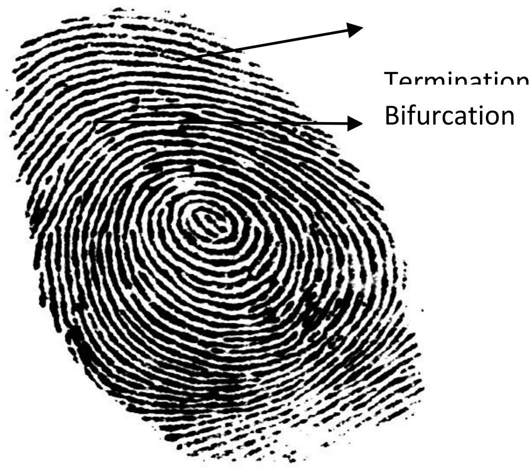

Figure 1: Sample Fingerprint

Fingerprint identification was first done in the year 1892 by Juan Vucetich. Since then, it has been subject to several technological changes made to keep it fool proof. There were several rudimentary methods used for verification. By the 1900s it was found that these methods were not entirely fool proof and that they only took into account the positions of unique points called ridges. Consequently, more techniques were developed to take into account the alignment and relative positions of these ridges. All fingerprints consist of minutiae, which are of two types, namely, bifurcations and terminations after several scientific advancements, by the year 2013, Multinational Companies (MNCs) such as Motorola and Apple.inc sold mobile phones with fingerprint based biometric security [1].

Fingerprint Verification system is one of the most significant and common biometric technologies mostly because of its uniqueness and its ease of use compared to passwords and other security systems. Fingerprints have been used for identification for personal and official purposes for several years. It has recently become automated due to advancement in computing capabilities. Due to the fact that it is relatively more fool proof when compared to passwords and patterns [2], fingerprint security system is now days used in a various applications such as banking ,mobile security ,biometric attendance, network fields, etc. Fingerprint identification system mainly depends on the unique(no two individuals have the same fingerprints) finger lines known as minutia ,owing to which, all people can use this system because of its distinctiveness, ease of acquisition and high matching accuracy rate.

RELATED WORK

In this section the various techniques that can be used to compare and verify fingerprints are discussed. These techniques include direct matching, ridge detection and relational distance matching. In this paper ridge detection technique is used. This techniques involves the identification of the several minutiae points present on the surface of the finger. The orientation of these minutiae points is identified and stored in the database to be used as reference for comparison. However there are other methods available to verify fingerprints. Direct matching can also be used to perform this. Direct matching [3] involves the comparison of fingerprints pixel wise. Due to pixel matching, the time consumed by this process is longer as compared to ridge detection technique. In relational distance matching a set of minutiae points that are common to the reference image and input image is obtained. This set is called as tuple. Various fingerprint tuples can be used for verification. Ridge detection is the most common technique used. This algorithm can be further divided into three stages.

1. Pre-Processing Stage
2. Identification of ridges
3. Minutiae elimination and orientation.

Pre-processing stage is used to enhance the overall quality of the image [4A]. Ridge thinning is done to ensure that unnecessary pixels are eliminated [4]. This helps us in the identification of the termination and bifurcation points. However it also results in the generation of spurious minutiae. This is eliminated and the orientation of these points is identified.

PROPOSED METHOD

The proposed method is shown as a flow chart in Figure 2**.** A greyscale image of the fingerprint is taken and it is enhanced to make ridges clearly visible. From the enhanced image the various terminations and bifurcations are identified. This results in the generation of spurious minutiae. Suppression of spurious minutiae is done by identifying the area of interest and also the Euclidean distance. The significant minutiae are then obtained. The orientation of these significant ridges is found. This information is stored in the database and is used for comparing and verifying with a sample image.

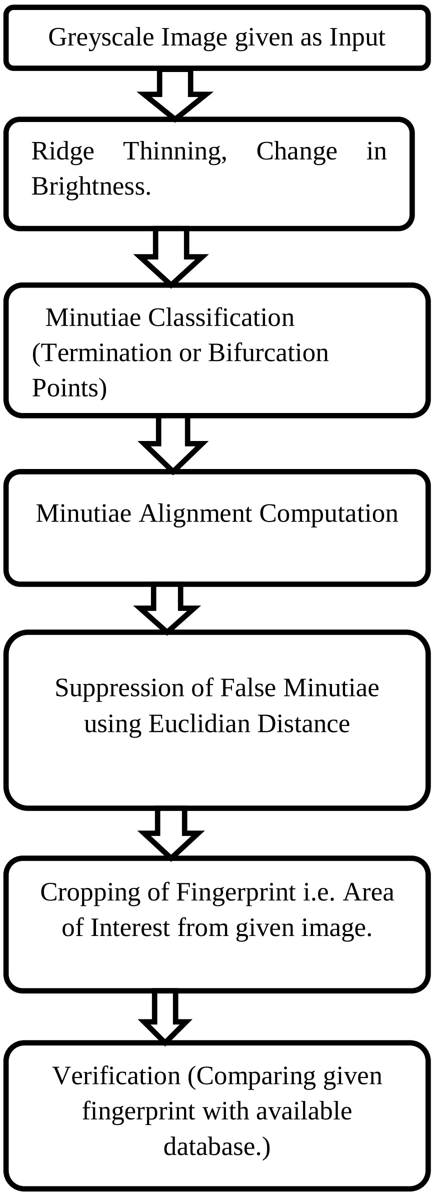

Figure 2. Flow chart of proposed method

Input Image

The process starts with the input image being enhanced for further steps. This is a necessary step since the image needs to be clear and distinctive in order to show even the slightest differences among minutia. The given input must be a greyscale image, but since the subject here is fingerprints, it is assumed that the input image is greyscale.

Ridge Thinning

This involves ridge thinning in which spurious or redundant pixels are eliminated until the ridges are only one pixel wide. The greyscale input image is converted into a binary image. The morphological function in MATLAB is used in this process. Thin operator is used to shrink the ridges to a minimally connected stroke. This is repeated till there is no change in the image. This ensures maximum enhancement and makes the image ready for the pre-processing stage.

Minutiae Classification

Terminations are ridge ending points and thus have only one neighbour pixel. They are the most common type of minutiae.

Steps for the identification of termination points

1. The image is broken down into several matrix windows of size 3x3.
2. The pixel in the centre of the matrix is taken into consideration and the adjacent pixels are used to identify minutiae points.
3. If the pixel has simply one neighbour with a non-zero value then it is a termination point.
4. These points are marked using a red circle.
5. This process is repeated until all the termination points in the image are identified.

0	0	0
0	X	0
1	0	0

Figure 3: A 3x3 mask for termination detection.

Bifurcations are points at which a single ridge splits into two. They are less common, having three neighbour pixels. The centroid function is used to locate the positions of the minutia.

Steps for the identification of bifurcation points

1. The image is broken down into several matrix windows of size 3x3.
2. The pixel in the centre of the matrix is taken into consideration and the adjacent pixels are used to identify minutiae points.
3. If the pixel has three neighbours with a non-zero value then it can be as a bifurcation point.
4. These points are marked using a green circle.
5. This process is repeated until all the bifurcation points in the image are identified.

1	0	1
0	X	0
1	0	0

Figure 4: A 3x3 Mask for bifurcation detection.

Figures 3 and 4 show the 3 X 3 pixel windows for termination and bifurcation points respectively

Minutiae Alignment Computation

Once the minutia is identified, their respective orientations must be determined with respect to one another. The position of termination and bifurcation in an image can be identified uniquely by using the parameters x, y and θ where x and y are the position of the minutiae in the coordinate axis and θ is the corresponding minutiae angle. In order to do this, the pixels of ridge endings and bifurcation are analysed. For termination points this process is done once and for bifurcation it is done thrice. After the orientation of each minutia with respect to one another is analysed, the image is almost ready for verification [5]. However, due to the existence of far too many termination and bifurcation points, the computation becomes complex and time consuming. Thus the need arises to take only certain dominant minutia into consideration. Therefore, a set of suppression processes are used, to detect and suppress false or spurious minutia [6].

Suppression of false minutiae

The various minutiae points can be obtained by processing the image using termination and bifurcation algorithm and these points are indicated using circles as shown in figure 3. However this also results in the generation of spurious minutiae. These minutiae play an insignificant role in the verification process. Hence they are eliminated using the minutiae suppression algorithm [7].

This occurs in three stages, in which spurious terminations and bifurcations are eliminated by calculating the distances between them separately. The first primary suppression stage compares distances between ridge endings(termination points) while the second primary suppression stage compares distances between Bifurcation points. The secondary suppression stage finally compares the distances between termination points and bifurcation points. After the secondary suppression, the image is now left only with dominant points.

Stage 1

The **Euclidean or straight line distance** between a termination point and bifurcation point is found and it is compared with threshold distance D. If it is smaller than D then the corresponding minutiae points are removed.

P_T - Termination point

P_B - Bifurcation point

D_{Th}- Threshold distance

$D_{P_T - P_B} < D_{Th}$ (1)

Stage 2

The **Euclidean or straight line** distance between two bifurcation points is found and it is compared with the threshold distance D. If it is smaller than D then the corresponding minutiae points are removed.

$D_{P_{B1} - P_{B2}} < D_{Th}$ (2)

Stage 3

The **Euclidean or straight line** distance between two termination points is found and it is compared with the threshold distance D. If it is smaller than D then the corresponding minutiae points are removed.

$D_{P_{T1} - P_{T2}} < D_{Th}$ (3)

From the figure it is clearly visible that the spurious minutiae have been eliminated and only the significant termination and bifurcation points are present.

Cropping of fingerprint (AOI) from image

The penultimate step before verification is the computation of the Area of Interest (AoI).The Area of interest is the most significant region of the image, which consists of the dominant termination and bifurcation points. Anything outside the AoI is eliminated (or suppressed).

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To obtain the AoI the image is converted to the binary form [7]. This is then eroded using the erode function in MATLAB to obtain the AoI.

This AoI is then multiplied with the linear value of the image that is calculated using the index function also available in MATLAB. The image obtained is used to identify orientation of the termination and bifurcation points.

Verification

The final step is the verification of one fingerprint with another. In a Graphical User Interface (GUI), this is done after the feature extractions of the two fingerprints being compared for verification. Every image is a 2D matrix, which can be converted using the sub2index MATLAB function, to its unique linear value.

Once the values are computed, they are compared with respect to the positions and alignments of the minutia of the two fingerprints and the authentication message is displayed.

RESULTS AND DISCUSSIONS

Based on the findings in this work, it is clear that the identification and matching of fingerprints depends primarily on the ridge ending and bifurcation present. The greyscale image in figure 5(a) is taken as the input for this work. This image is then enhanced. Enhancing is done using the thin operator under morphological function in MATLAB in order to obtain thinner ridges. The resultant fingerprint after carrying out ridge thinning is shown in figure 5(b). After this process the various termination and bifurcation present are identified.

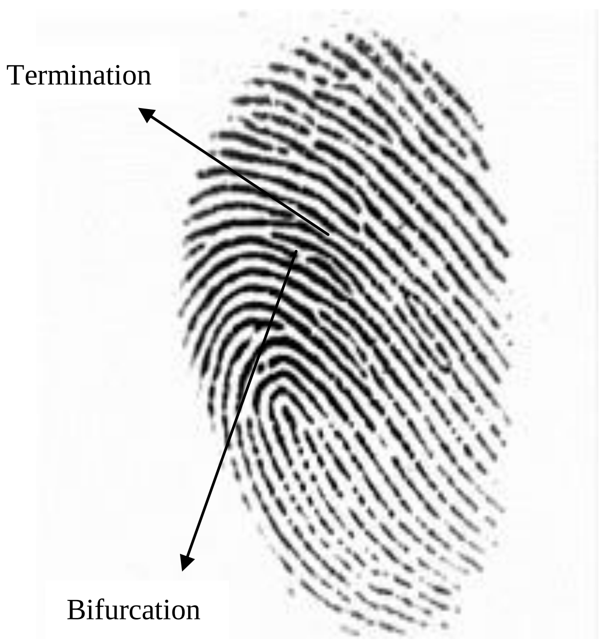

FIGURE 5(a): Input Image

FIGURE 5(b): Ridge thinning

The algorithm proposed in this work is used to obtain these points. These minutiae points are shown in figure 5(c). The red circles and green circles in the image represent the termination and bifurcation respectively. It is clear that the number of termination points in the fingerprint is much higher than that of bifurcation points. The edges of the images are padded so that these ridge points can be identified.

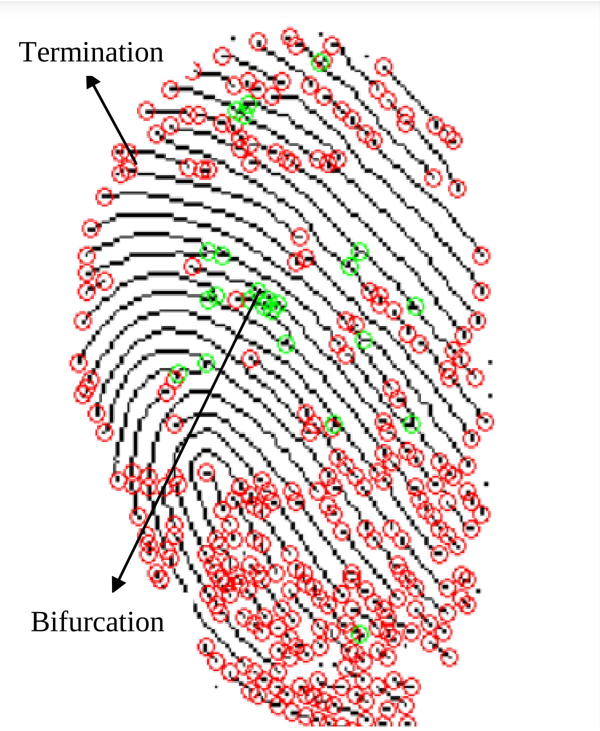

FIGURE 5(c): Termination and Bifurcation.

However, processing of image using this algorithm also results in the generation of spurious or false minutiae. These minutiae have to be eliminated so that the significant termination and bifurcation points can be obtained. Area of interest (AoI) can be used to eliminate a large number of false minutiae.

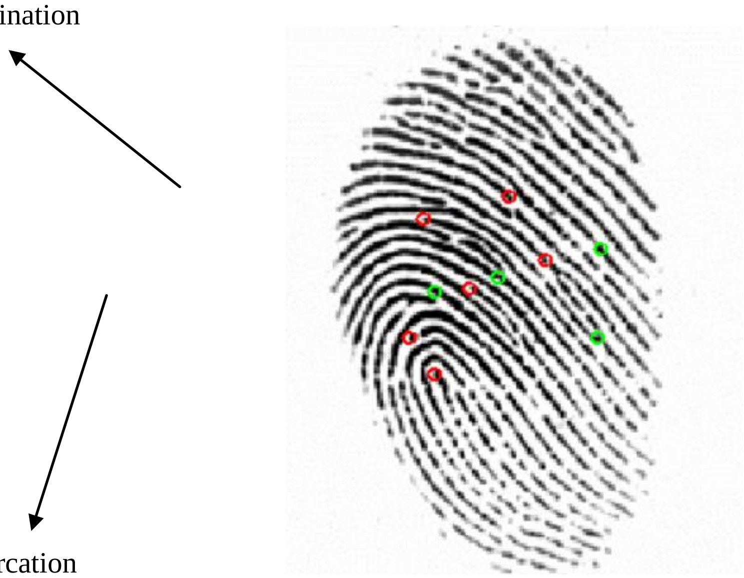

FIGURE 5(d): False Minutiae suppression

This AoI is obtained by using the erode function available in MATLAB. The eroded image is used to eliminate the spurious minutiae from the scanned image of the fingerprint. Figure 5(d) shows the image of the fingerprint after the elimination of spurious minutiae. The termination and bifurcation present after this process are the significant minutiae. The position of these points in coordinate axis and the minutiae angle is stored in the database and is used for the purpose of verification.

Table 1 Comparison of processing time

Method	**Processing Time (seconds)**
Direct Matching	3.6
Minutiae based matching	3

From Table 1 it is clear that the time required for processing and comparing a fingerprint using direct matching is much higher than that of minutiae based matching [3]. This proves to be very useful when a database consisting of several fingerprints is compared and verified.

Table 2 Comparison of False acceptance and False rejection rate among various sample databases.

Methods	False Acceptance Rate	False Rejection Rate
Sample Database 1	15%	15%
Sample Database 2	10%	10%
Sample Database 3	10%	20%
Average	11.67%	15%

Table 2 shows the numerical results for three sets of fingerprints developed by the user. Database 1 and Database 2 were made up of 20 fingerprints while Database 3 comprised of 10 fingerprints. The corresponding false acceptance and false rejection rates are shown in Table 2.

.Despite the wide use of the given method, there is still scope for improvements in terms of error rates and other factors. This method of scanning a finger is not always immune to external disturbance. The image of fingerprint is captured using a scanner and external factors such as dirt, condition of the surface of the skin, alignment may affect the quality of the image. Due to this, research and development departments of several Government agencies and private corporations have developed methods which use computational geometry to give better precision despite higher cost. In these methods, the features depend entirely on the degree of brightness of the pixel in the fingerprint image, in contrast to conventional methods where features are extracted using edges, minutiae points and ridges present. This gives a trade-off between higher precision (lower error rates) and higher cost (and higher time delay), making the ridge detection method preferable in scenarios where usage is quite high.

CONCLUSION

The major steps involved in this work is summarised as follows; Identification of termination and bifurcation points, elimination of the specious minutiae, localising the AoI and finding orientation of the minutiae points.

Minutiae based matching fingerprint takes less time than direct matching method. The False Acceptance Rate and False Rejection Rate has to be reduced to single digit for widespread acceptance of this technique.

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