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Fingerprint Recognition System

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Abstract- The popular Biometric used to authenticate a person is Fingerprint which is unique and permanent throughout a person's life. A minutia matching is widely used for fingerprint recognition and can be classified as ridge ending and ridge bifurcation. In this paper we projected Fingerprint Recognition using Minutia Score Matching method (FRMSM). For Fingerprint thinning, the Block Filter is used, which scans the image at the boundary to preserves the quality of the image and extract the minutiae from the thinned image. The false matching ratio is better compared to the existing algorithm.

Keywords – ***Fingerprint Recognition, Binarization, Block Filter Method, Matching score and Minutia***

I. INTRODUCTION

A. Biometric Recognition

It refers to the use of distinctive anatomical (e.g., fingerprints, face, iris) and behavioral (e.g., speech, gait, signature) characteristics, called biometric identifiers or traits or characteristics for automatically recognizing individuals. Biometrics is becoming an essential component of effective person identification solutions because biometric identifiers cannot be shared or misplaced, and they intrinsically represent the individual's bodily identity [1]. No single biometric is expected to effectively meet the requirements of all the applications. Fingerprint recognition has a very good balance of all the properties. A number of biometric characteristics are being used in various applications as Universality, Uniqueness, Permanence, Measurability, Performance, Acceptability, and Circumvention [2]

(i) Fingerprint

A fingerprint is the feature pattern of a finger as shown in figure 1. It is believed with strong evidences that each fingerprint is unique. Each person has his own fingerprints with the permanent uniqueness. So fingerprints have being used for identification and forensic investigation for a long time. A fingerprint is composed of many ridges and furrows. These ridges and furrows present good similarities in each small local window, like parallelism and average width. The two most prominent local ridge characteristics, called minutiae, are 1) Ridge ending and 2) Ridge bifurcation.[3]. A good quality fingerprint contains 25 to 80 minutiae depending on sensor resolution and finger placement on the sensor. The false minutiae are the false ridge breaks due to insufficient amount of ink and cross-connections due to over inking. It is difficult to extract reliably minutia from poor quality fingerprint impressions arising from very dry fingers and fingers mutilated by scars, scratches due to accidents, injuries.

The motivation behind the work is growing need to identify a person for security. The fingerprint is one of the popular biometric methods used to authenticate human being. The proposed fingerprint verification FRMSM provides reliable and better performance than the existing technique.

In this paper we used Fingerprint Recognition using Minutia Score Matching method with the help of MATLAB codes. Minutiae are extracted from the thinned image for both template and input image. Finally both the images are subjected to matching process and matching score is computed.

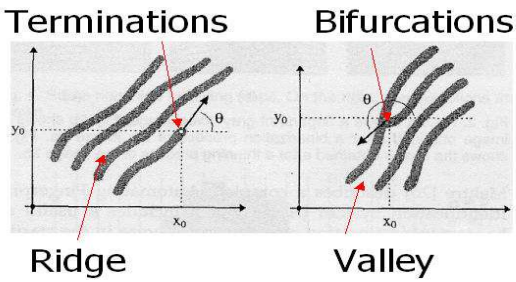


Figure1.Ridge and bifurcation of the finger print

(ii) Fingerprint recognition

The fingerprint recognition problem can be grouped into three sub-domains: fingerprint enrollment, verification and fingerprint identification. Verification is typically used for positive recognition, where the aim is to prevent multiple people from using the same identity. Fingerprint verification is to verify the authenticity of one person by his fingerprint. There is one-to-one comparison in this case. In the identification mode, the system recognizes an individual by searching the templates of all the users in the database for a match. Therefore, the system conducts a one to-many comparison to establish an individual's identity [4].

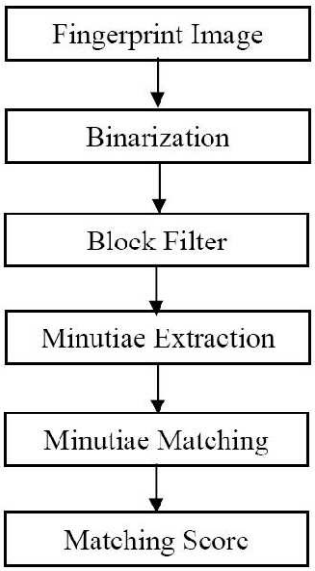


Figure 2 Block diagram of FRMSM

(iii) Model

In this section the definitions and FRMSM model are discussed

a. *Definitions:*

Termination **:** The location where a ridge comes to an end.

Bifurcation **:** The location where a ridge divides into two separate ridges.

Binarization **:** The process of converting the original grayscale image to a black-and white image.

Thinning **:** The process of reducing the width of each ridge to one pixel

Termination Angle **:** The angle between the horizontal and the direction of the ridge.
Bifurcation Angle **:** The angle between the horizontal and the direction of the valley ending between the bifurcations.
False Matching Ratio **:** It is the probability that the system will decide to allow access to an *(FMR)* imposter is given in an equation (1)

FMR = False Matches / Im poster Attempts -------(1)

The imposter attempts are implemented by matching each input image with all the template images. False match was recorded for each imposter attempt when the matching score was greater than the established threshold. *False Non Matching Ratio (FNMR):* It is the probability that the system denies access to an approved user is given in an equation (2)

FNMR = FalseNonMatches / EnrolleAttempts ------(2)

Enrollee attempts are implemented by matching each input image with corresponding template image, hence it is one-to-one matching. A False Non-match was recorded when the matching score between an enrollee and its template was less than the established threshold.
Matching Score: it is used to calculate the matching score between the input and template data is given in an equation (3)

Matching score = Matching Minutiae / Max(NT,NI) -------(3)

Where, *NT* and *NI* represent the total number of minutiae in the template and input matrices respectively. By this definition, the matching score takes on a value between 0 and 1. Matching score of 1 and 0 indicates that data matches perfectly and data is completely mismatched respectively.

b. Model

Fingerprint Image*:* The input fingerprint image is the gray scale image of a person, which has intensity values ranging from 0 to 255. In a fingerprint image, the ridges appear as dark lines while the valleys are the light areas between the ridges. Minutiae points are the locations where a ridge becomes discontinuous. A ridge can either come to an end, which is called as termination or it can split into two ridges, which is called as bifurcation. The two minutiae types of terminations and bifurcations are of more interest for further processes compared to other features of a fingerprint image.

Binarization: The pre-processing of FRMSM uses Binarization to convert gray scale image into binary image by fixing the threshold value. The pixel values above and below the threshold are set to '1' and '0' respectively. An original image and the image after Binarization are shown in the Figure 2.

(A) (B)

Figure 3: (A) Original Fingerprint (B) Binarized image.

Minutiae Extraction: The minutiae location and the minutiae angles are derived after minutiae extraction. The

terminations which lie at the outer boundaries are not considered as minutiae points, and Crossing Number is used to locate the minutiae points in fingerprint image. Crossing Number is defined as half of the sum of differences between intensity values of two adjacent pixels. If crossing Number is 1, 2 and 3 or greater than 3 then minutiae points are classified as Termination, Normal ridge and Bifurcation respectively, is shown in figure 4.

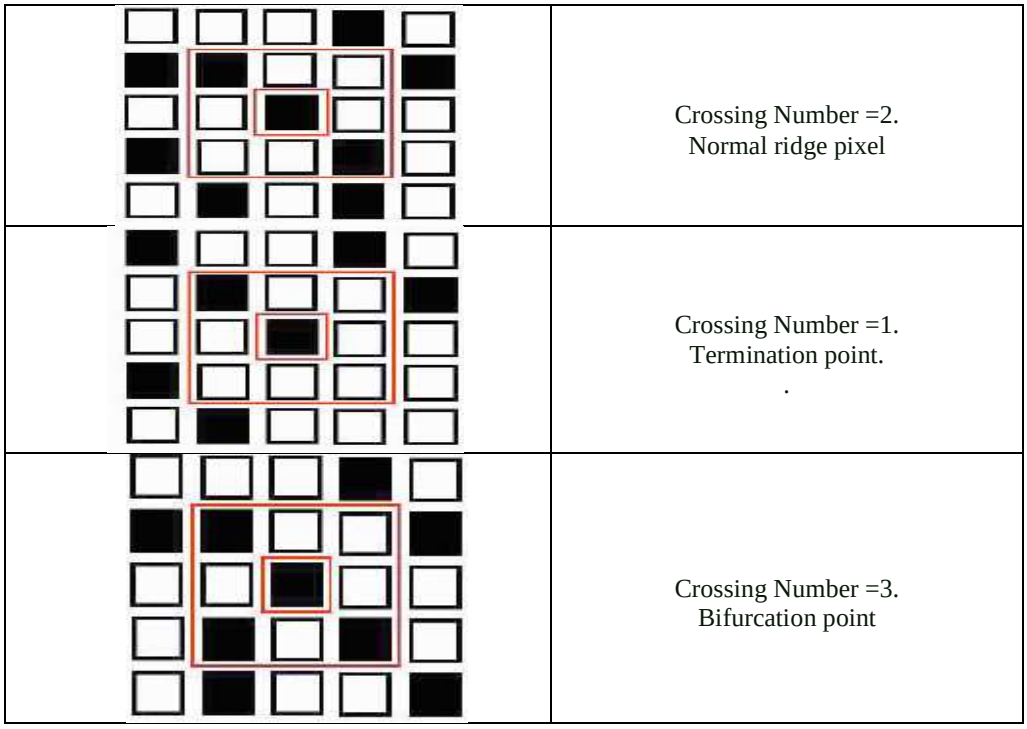
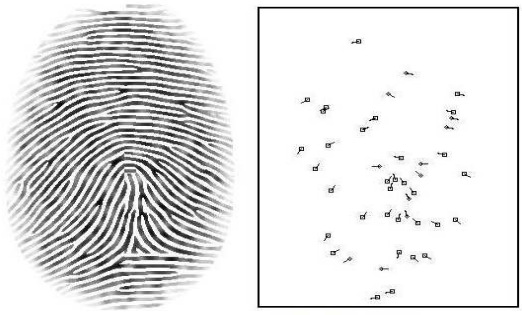


Figure 4: Crossing Number and Type of Minutiae.

To calculate the bifurcation angle, we use the advantage of the fact that termination and bifurcation are dual in nature. The termination in an image corresponds to the bifurcation in its negative image hence by applying the same set of rules to the negative image, we get the bifurcation angles.

Figure 5 shows the original image and the extracted minutiae points. Square shape shows the position of termination and diamond shape shows the position of bifurcation as in figure 5 (b)



(a) (b)

Figure 5: (a) Gray-scale Fingerprint (b) Minutiae points.

Minutiae Matching: To compare the input fingerprint data with the template data Minutiae matching is used. For efficient matching process, the extracted data is stored in the matrix format. The data matrix is as follows.
Number of rows: Number of minutiae points.
Number of columns: 4
Column 1: Row index of each minutia point.
Column 2: Column index of each minutia point.
Column 3: Orientation angle of each minutia point.
Column 4: Type of minutia. (A value of '1' is assigned for termination, and '3' is assigned for bifurcation).
During the matching process, each input minutiae point is compared with template minutiae point. In each case, template and input minutiae are selected as reference points for their respective data sets. The reference points are used to convert the remaining data points to polar coordinates. The Equation (4) is used to convert the template minutiae from row and column indices to polar coordinates.

$$\begin{matrix} r_k^t \\ \emptyset_k^t \\ \theta_k^t \end{matrix} = \begin{matrix} \sqrt{\left(row_k^t - row_{ref}^t\right)^2 + \left(col_k^t - col_{ref}^t\right)^2} \\ \tan^{-1}\dfrac{\left(row_k^t - row_{ref}^t\right)}{\left(col_k^t - col_{ref}^t\right)} \\ \theta_k^t - \theta_{ref}^t \end{matrix} \qquad \text{----------(4)}$$

Where, for a template image,
r_k^t = radial distance of k^{th} minutiae.

$\emptyset_k^t$ = radial angle of k^{th} minutiae.
θ_k^t =orientation angle of k^{th} minutiae.

row_{ref}^t , col_{ref}^t = row index and column index of reference points currently being considered.

Similarly the input matrix data points are converted to polar coordinates using the Equation (5)

$$\begin{matrix} r_m^I \\ \emptyset_m^I \\ \theta_m^I \end{matrix} = \begin{matrix} \sqrt{\left(row_m^I - row_{ref}^I\right)^2 + \left(col_m^t - col_{ref}^I\right)^2} \\ \tan^{-1}\dfrac{\left(row_m^I - row_{ref}^I\right)}{\left(col_m^I - col_{ref}^I\right)} + rowvalues(k,m) \\ \theta_m^I - \theta_{ref}^I \end{matrix} \qquad \text{----------(5)}$$

Rotate values (k, m) represents the difference between the orientation angles of *Tk* and *Im*. *Tk* and *Im* represent the extracted data in all the columns of row *k* and row *m* in the template and input matrices, respectively.

II. PROPOSED ALGORITHM

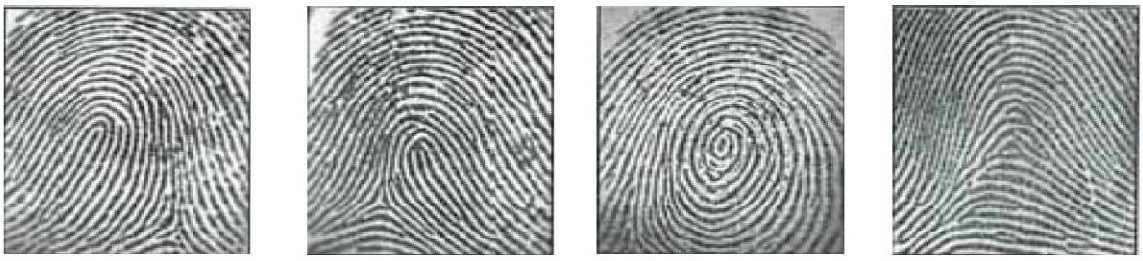
Problem definition**:** Given the test Fingerprint Image the objectives are,
1. Pre-processing the test Fingerprint.
2. Extract the minutiae points.
3. Matching test Fingerprint with the database.

Table -1 Algorithm of FRMSM

Input: Gray-scale Fingerprint image.
Output: Verified fingerprint image with matching score.
1. Fingerprint is binarized
2. Thinning on binarized image
3. Minutiae points are extracted. Data matrix is generated to get the position, orientation and type of minutiae.
4. Matching of test fingerprint with template
5. Matching score of two images is computed, if matching score is 1 images are matched and if it is 0 then they are mismatched.

III. PERFORMANCE ANALYSIS AND RESULT

For performance analysis, we considered large fingerprint database images having different patterns such as fingerprint left loop, right loop, whorl and arch as shown in the Figure 6.



(a) lcft loop **(b) right loop** **(c) whorl and** **(d) arch**

Fig 6: Samples of fingerprint images

Table 2 gives the comparison of False Non Matching Ratio (FNMR) and False Matching Ratios (FMR) for existing method of Fingerprint Recognition Fuzzy Neural Network (FRFNN) and proposed method of Fingerprint Recognition using Minutia Score Matching method (FRMSM). It is observed that the False Non Matching Ratio for both the methods is zero and False Matching Ratio for existing method is 0.23 whereas for the proposed method FRMSM is 0.026.

	FRFNN	**FRMSM**
FNMR	0.00	0.00
FMR	0.23	0.026

IV.CONCLUSION

In this paper, we presented Fingerprint matching using FRMSM. The pre-processing the original fingerprint involves image binarization, ridge thinning, and noise removal. Fingerprint Recognition using Minutia Score

Matching method is used for matching the minutia points. The proposed method FRMSM gives better FMR values compared to the existing method.

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