ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, No 5, May 2013

AN EFFECTIVE METHODOLOGY FOR MINUTIAE BASED FINGERPRINT MATCHING USING SINGULARITIES INDEXING

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Abstract- Fingerprint is one of the most significant and traditional biometric trait and its uniqueness are exclusively determined by the local ridge characteristics and their relationships. However, in existing system, due to variations in impression condition, due to different stress level, ridge configuration, skin conditions, acquisition devices, noise etc, the accuracy of the system get affected. To overcome this problem, more number of different fingerprint classifiers are considered. This paper proposes a new effective methodology using minutiae matching technique along with singularities detection and indexing, based on the occurrences of singular points with reference to the core point. From the results, it shows this technique is effective and it is measured in terms of False Acceptance Rate (FAR) and False Rejection Rate (FRR).

Index terms: Biometrics, Fingerprint Recognition, Minutiae Matching, Pattern based Matching, Singularities indexing

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I.INTRODUCTION

Biometrics is the identification of an individual based on physical or behavioral characteristics of the person. Traditional methods of establishing a person's identity include knowledge based (e.g., passwords) and token-based (e.g., ID cards) mechanisms, but these substitution representation of identity can easily be faked or easily spoofed compromising the intended security. Hence the term biometrics came into existence, where the behavioral and the physiological characters are considered to overcome the drawbacks of the traditional system.

The physiological characteristics include eye (retina and iris), fingerprints, palm-prints, hand geometry and behavioral characteristics such as handwritten signature; voiceprint; gait; gesture; etc which are unique to every individual . Thus biometrics finds its application in various fields such as Commercial, Government, Research and Military.

The reference template which is an individual's first instance to the biometric system is enrolled into the database. In this enrolment phase, before storing the data into the database the image undergoes many stages. During the first stage, the image enters the pre processing phase where the noise removal in the image and enhancement of the image is

done. In the second stage, the images are segmented to particular areas known as areas of interest and the processing is mainly done in that area. Finally, the image enters the normalization stage where the image is normalized and the features are extracted and stored. These stages are the basic modules for any common biometric system.

During the matching process a trial template is obtained from the user and it undergoes all the stages. The features are matched with the stored features and the difference in their match is calculated with respect to the threshold by which it is authenticated. For all these stages various algorithms are used which are enhanced, changed or modified so that the accuracy of the system can be improved. Among all traits [1-2] fingerprint is a most commonly used traits for its uniqueness and permanence over time.

A new effective methodology for improving the accuracy and efficiency of a fingerprint verification system by using consistency of singular points along with minutiae points even in the distorted images by estimating the orientation field of each block to locate the core and delta points has been proposed, and also a new proposal of indexing, each template based on the occurrence of delta point with reference to the core point is attempted, and the results are obtained by implementing in Standardized dataset for fingerprint FVC[11], FAR and FRR levels are compared to the existing systems to analyze the performance of the proposed method.

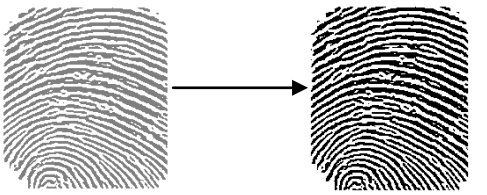
The rest of the paper is organized as follows: Section II describes the basic modules in fingerprint recognition system. Section III describes proposed work in fingerprint recognition system. And finally, Section IV draws some results and conclusion.

II. LITERATURE REVIEW

Minutiae based recognition [3,4] has been one of the most successful fingerprint recognition techniques used for personal identification. Minutiae points are these local ridge characteristics that occur either at a ridge ending or a ridge bifurcation. A ridge ending [3,4] is defined as the point where the ridge ends abruptly and the ridge bifurcation is the point where the ridge splits into two or more branches. The minutiae algorithm locates the ridge bifurcation and ridge ending. From the FVC [11] database, the fingerprint input image (TIFF), locate all the visible minutiae points. Now the minutiae points are stores as the string of numbers for the given input image. This process is called Fingerprint Identification or Fingerprint Feature Extraction. Next step is the authentication of any given fingerprint image. For this, an input fingerprint which is to be validated is extracted and all the minutiae points are compared with the previously stored fingerprint template image and authenticated. The basic steps involved in the fingerprint recognition system are mentioned below.

A.Image Binarisation

The input image is segmented to ensure the removal of noise. For this, the image is divided into blocks of size 16×16 and the variance of each block is less than the threshold value, then it is deleted from the original figure. This process is carried out for the whole image.



Original image Normalized image
Fig 1: Normalization

B. Image Thinning

Using thinning process, the image is thinned in order to remove the noise. For this purpose, the frequency of the local blocks using Gabor filter based matching X-signatures of each block are computed along the direction perpendicular to the orientation angle in each block. The window used for this purpose is of size 16×32. The frequency is then computed by the distance between the peaks obtained in the X-signatures.

Normalized image Thinned image

Fig 2: Binarisation

C. Minutiae Extraction

The next step is to extract the minutiae points from the input image. As a result of thinning process, the skeleton of the image is formed, in which a ridge is only a pixel wide. Then minutiae are extracted using Neighborhood Operation [4], where ridge endings are those, which have a pixel value of one as its neighbor and ridge bifurcations are those which have a pixel value of more than two ones.

Thinned image Minutiae

Fig 3: Minutiae Extraction

D. Minutiae Matching

The matching phase validates the similarity metrics between two fingerprint representations and authenticates it. The string of numbers holding the properties of the minutiae points of reference template are matched with the corresponding trial template identifies by the key id.

$$T=\{m_1 m_2 \ldots m_n\} \quad (1)$$

$$m_i=\{x_i, y_i, \theta_i\}\ i=1..m \quad (2)$$

$$I=\{\dot{m}_1 \dot{m}_2 \ldots \dot{m}_n\} \quad (3)$$

$$\dot{m}_j=\{\dot{x}_j, \dot{y}_j, \dot{\theta}_j\}\ j=1..n \quad (4)$$

A minutiae m_j' in I and a minutiae m_i in T are considered to be matched if their spatial and orientation differences are within specified thresholds r_o and θ_o. In this approach the minutiae sets ate first registered using a derivative computation. The matching algorithm returns a percentage match score, if the match score is within the threshold limit the system allows the image else rejected.

III. PROPOSED WORK

The core points are more constant even for distorted image. So, to add reliability of the minutiae based matching in the proposed system, core point is considered as a prime factor, and is detected using the centralizing algorithm then the orientation field estimation of the ridge is closely detected using the interpolation algorithm [6], so that the delta points too can be detected by finding the Poincare index value. In order to increase the accuracy even for worst case images [4, 11], singularities detections are used for indexing based on its occurrences with reference to core point.

A.Core Point Detection

Initially, the directional flow of ridges is computed for estimating the orientation

field. The image is tilted to 20 degree, and the sum of angle of difference is computed after that, with reference to the sum of angle difference of each block that's a pixel surrounded by 8 pixels 3×3. The centralizing is carried out as shown in the figure 4

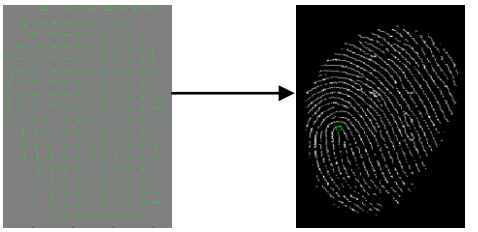


Fig 4: Core Point Detection

B. Delta Point Detection

The delta points are located based in the Poincare index value [9]. Each block of 3×3 matrix is considered. The sum of angle difference of each block is calculated, and it is called as Poincare index.

- If the Poincare index is equal to 360 degree (threshold), it is a core point
- If the Poincare index is greater than 180 degree (threshold), it is a delta point.

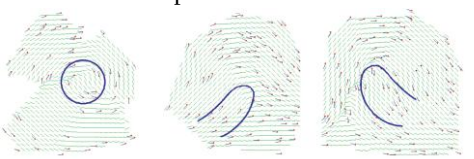


Fig 5: Delta Point Detection

The Poincare index value is represented using,

$$P_{G,C}(i,j) = \sum_{k=0,\ldots,7} angle(d_k, d_{(k+1)mod8})$$

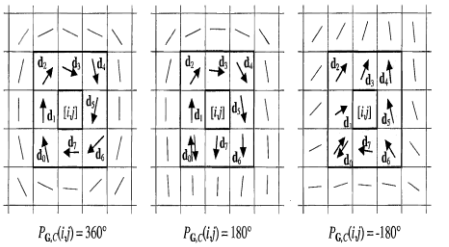


Fig: 6 Poincare Indexing

C. Singularities Indexing

With reference to the core point, the maximum occurrence of delta points are noted based on the maximum occurrence towards the quadrant the flags are set as below

- 00 - Maximum occurrences of delta points in (x,y)
- 01 - Maximum occurrences of delta points in (-x,y)
- 10 - Maximum occurrences of delta points in (-x,-y)
- 11 - Maximum occurrences of delta points in (x,-y)

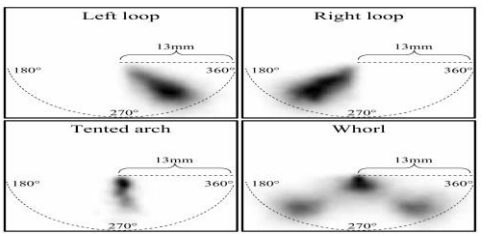


Fig: 7 Singularities Indexing

D. Matching

The templates are stored as the string of numbers in the following patterns in order to make the matching speedily as shown below in the figure 8

Flag	C_n	(x_c,y_c)	n	(x_n,y_n, θ_n)

Fig: 8 Storage Representation of Template

Where,

Flag – Two byte binary no, to indicate the maximum occurrence of delta points with reference to core point.

C_n – Core point number

X_c , Y_c – x,y coordinates of core point.

n – no.of minutiae points

(X_n,Y_n,θ_n) – spatial and orientatioin coordinates of minutiae points.

Once the trial template is accessed, the two bytes flag is first inspected, based on the flag and core points x,y co-ordinates, the occurrence of the delta points are compared . If it matches, half the score is allocated to the template and for the remaining half the minutiae points are matched with liberal threshold since singular points which is consistent is matched with strong threshold. Finally based on the hamming distance value between the metrics the match score is generated and compared with the threshold and validation is done.

IV. RESULTS AND DISCUSSION

The performance of the system is evaluated by conducting some experiments using the standardized databases. The specification of the database is given in the Table 1. The fingerprint images in the database vary in quality, stress level, orientation etc. For fingerprint, FVC2006 database with datasets DB1_A, DB2_A, DB3_A and DB4_A are used in which more than half of the database has finger print images of acceptable quality and remaining images are highly distorted. The Table2 and 3 shows the comparison of the existing and proposed algorithm results for two different thresholds (20 and 25) of the finger print recognition. The Table shows that the proposed algorithm shows better results.

Table 1: Fingerprint Database Specification

Database FVC 2006	No. of Images	No .of Instances	Size	Quality
Db1_A	100	8	640 x 480	Distorted
Db2_A	100	8	640 x 480	Medium
Db3_A	100	8	640 x 480	Medium
Db4_A	100	8	640 x 480	Good

Table 2: Fingerprint Recognition – Recognition Rate vs Rejection Rate T = 20

FVC2006	Recognition Rate (%)		Rejection Rate (%)	
	Existing	Proposed	Existing	Proposed
DB1_A	97.25	98.15	7.5	6.5
DB2_A	98.15	98.84	11.2	10.3
DB3_A and DB4_A	98.75	99.47	9.63	9.15

For each and every table a graph is plotted namely Receiver Operator Curve (ROC) which shows the performance of the both existing and the proposed system in terms of False Acceptance Rate

(FAR) AND False Rejection Rate (FRR).

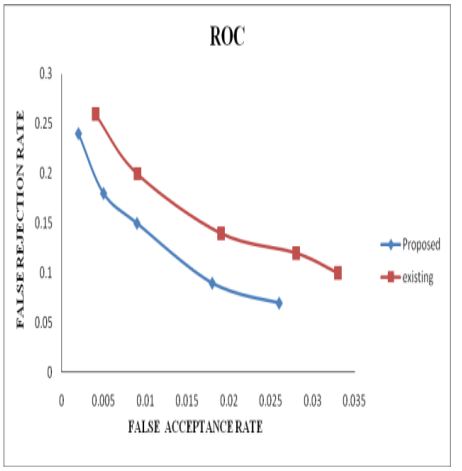


Figure 9: ROC GRAPH – Performance evaluation of Fingerprint Recognition for DB1_A and DB2_A with T=20

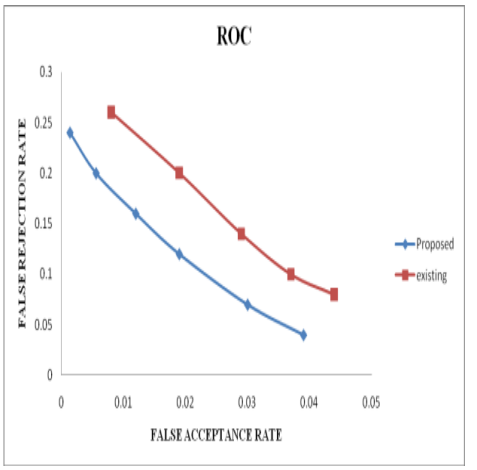


Figure 10: ROC GRAPH – Performance evaluation of Fingerprint Recognition for DB3_A and DB4_A with T=20

Table 3: Fingerprint Recognition – Recognition Rate vs Rejection Rate T = 25

FVC2006	Recognition Rate (%)		Rejection Rate (%)	
	Existing	Proposed	Existing	Proposed
DB1_A	97.10	97.93	7.9	6.7
DB2_A	97.95	98.64	12.2	11.13
DB3_A And DB4_A	98.35	99.25	10.89	9.10

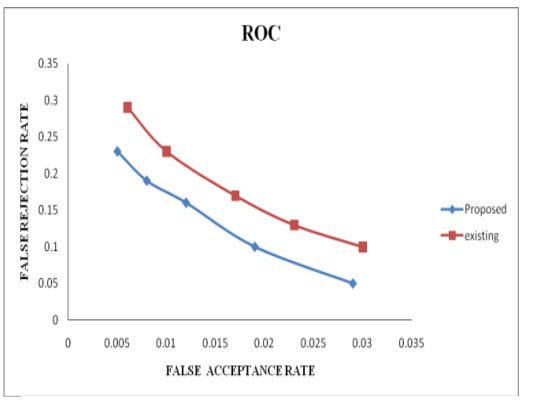


Figure 11: ROC GRAPH – Performance evaluation of Fingerprint Recognition for DB1_A and DB2_A with T=25

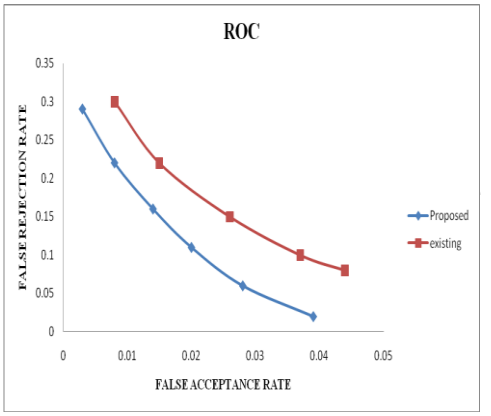


Figure 12: ROC GRAPH – Performance evaluation of Fingerprint Recognition for DB1_A and DB2_A with T=25

V. CONCLUSION

The existing system with minutiae matching techniques shows results of 99.25% ., and the proposed system which includes the singular points detection and indexing based on the maximum occurrence of delta points with reference to the core point shows the results of 99.65% . With reference to the test cases, it is found that the false acceptance rate and false rejection rate in minimized, even for distorted images since constant singularities are considered.

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