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Fingerprint Recognition using Local and Global Structures

Niharika Modi[1], Annapurna Mishra[2], Nalini Singh[3]

Student, Department of Electronics and Communication, Silicon Institute of Technology, Bhubaneswar, India[1]

Faculty, Department of Electronics and Communication, Silicon Institute of Technology, Bhubaneswar, India[2, 3]

Abstract: Fingerprint Recognition has been one of the important areas of research due to the ease of extraction of these features and its universal acceptability. One of the major challenges encountered in this method of recognition is the low quality of the fingerprints. This proposed hybrid method enhances the performance of the system by combining the minutiae based techniques with the global features based technique. This combination helps in achieving better rate of recognition especially when the fingerprint quality is low.

Keywords: Local features, Global structures,Singular points, Directional Field.

I. INTRODUCTION

Fingerprints are the most widely used parameter amongst all biometrics. A fingerprint is a unique pattern of ridges and valleys on the surface of a finger of an individual. Fingerprint is used because of its uniqueness, permanence, universal acceptability and ease of acquisition. Fingerprint identification is widely used in forensic science for investigation of crime scene. Fingerprints contain abnormal and unique points or discontinuities which are present on ridges and furrows known as Minutiae points. Minutiae points are of two types' ridge endings and ridge bifurcations as in Fig 1. Automatic Fingerprint Recognition system uses the two elementary types of minutiae features namely ridge terminations which refers to the immediate ending of the ridge and ridge bifurcations which is the point on ridge from which two branches are derived. These features can be seen in Figure 1[9].

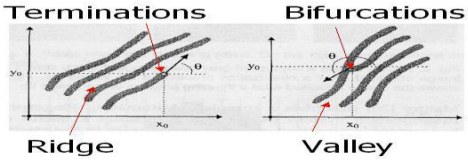

Fig 1. Terminations and Bifurcations

II. FINGERPRINT FEATURES

The fingerprint pattern when analyzed at different scales exhibits different types of features namely:-

At Level 1 or global level the ridge line flow delineates a pattern. External fingerprint shape, orientation field are the set of features which can be obtained at the global level.
At Level 2 minutiae [10,5] characteristics can be determined but these are not evenly distributed. Ridge endings and ridge bifurcations are the most prominent features used which are generally stable depending on the impression conditions. Fig. 2 shows the minutiae characteristics [3, 9].
At Level 3 or very fine level, intra ridge details can be detected like sweat pores. However extraction finer details requires high-resolution fingerprint image of good quality. Thus details not practical for non-forensic applications.

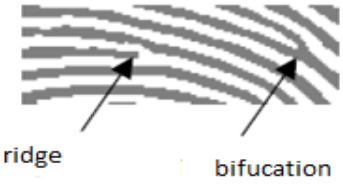

Fig 2. Minutiae characteristics

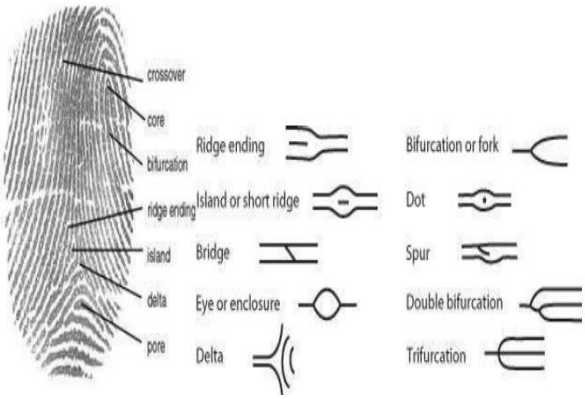

Fig 3. Types of Local Ridge Pattern

Fig 3 shows the different types of the local ridges that are present in the fingerprint.

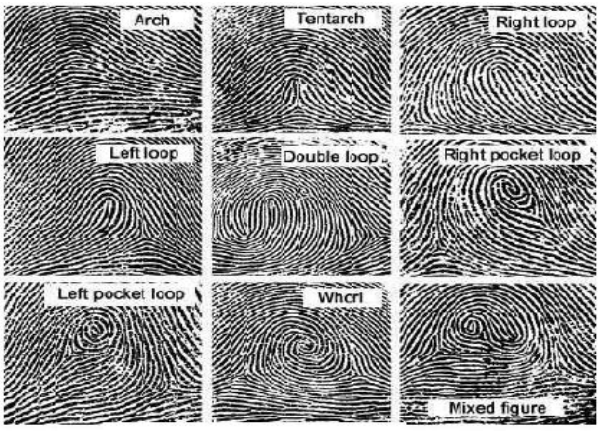

Fig 4. Global level features

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Fig 4. Shows the features at the global level which can be used for efficient recognition of the fingerprint.

III.FINGERPRINT RECOGNITION

Fingerprint Recognition

Fingerprint recognition refers to an automated method of verifying a match between two human fingerprints. Fingerprint Matching basically involves the comparison between several features of the print pattern [10]. These include patterns, which are aggregate characteristics of ridges and minutiae points [5], which are the unique features found within the pattern. Fig5. Shows the basic method of the fingerprint recognition.

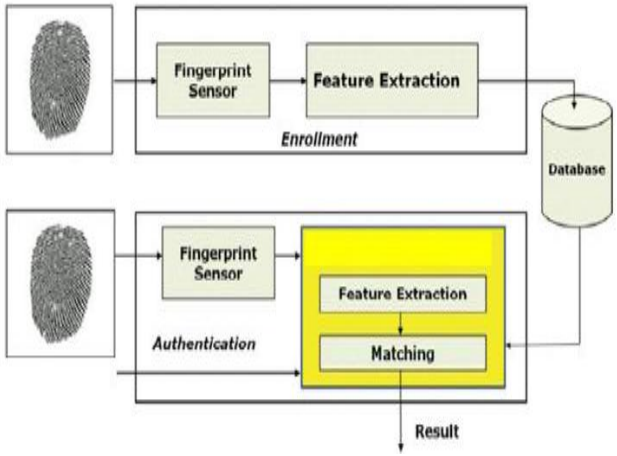

Fig 5. Block Diagram of Fingerprint Recognition

Different techniques of fingerprint matching [4, 6]:-

(i) Minutiae Extraction Based Technique: - This matching technique takes into consideration the fingerprint by its local features like termination and bifurcation [8]. A match is obtained between the minutiae points to see if the fingerprint is matched or not.

(ii)Pattern Matching or Ridge Feature Based Technique: - In this technique feature extraction is established on the basis of series of ridges as compared to the different minutiae points which design the basis of pattern matching over minutiae matching.

(iii)Correlation based technique: In this technique the fingerprints are adjusted and correlated to match each of the corresponding pixels. Here the ridge shape, breaks are taken for matching.

(iv)Image Based technique: - In this method the global features of the fingerprint images are matched.

Despite of the availability of several techniques for fingerprint matching, accurate match cannot be obtained. The use of correlation based technique [6] leads to lesser tolerance to non-linear distortion and contrast variations. It also enhances the computational complications. The pattern based matching technique [7] is acute to proper adjustment of the finger and has large storage space requirements.

The minutiae technique which uses minutiae points has several disadvantages [1] being a local feature ,it is quite difficult to extract the minutiae points as it is affected by various factors like noise , large displacement, different pressure ,etc. and the spurious minutiae generated tends to degrade the performance severely.

Hence we see that the use of the minutiae points only is not efficient enough determine the uniqueness of the fingerprint. So we have proposed a hybrid technique incorporating more discriminatory information available in the fingerprint images strongly improves the performance of the fingerprint matching systems.

IV. PROPOSED TECHNIQUE

In our proposed technique we use additional feature besides minutiae to implement matching so that better results can be obtained especially in the case of poor-quality images [1]. In the hybrid technique, we used global orientation information along with minutiae points. Figure 6 shows the basic processes involved in minutiae matching process.

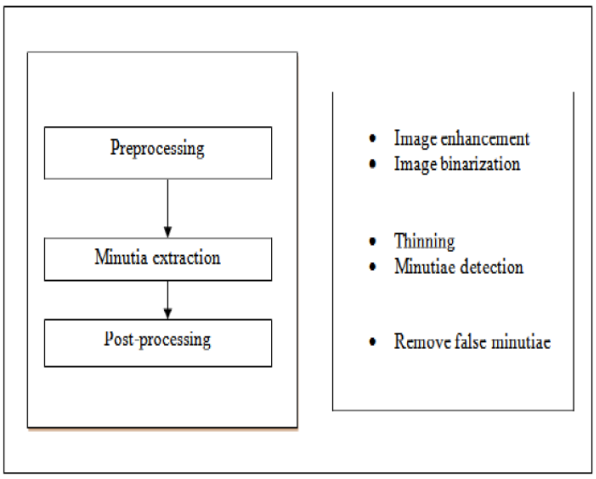

Fig 6. Basic technique of minutiae extraction

The orientation field estimate is included in this hybrid technique to obtain more accurate matching rates. The hybrid technique used here is the combination of the Minutiae matching with the orientation field estimate [1] as shown in the Fig 7.

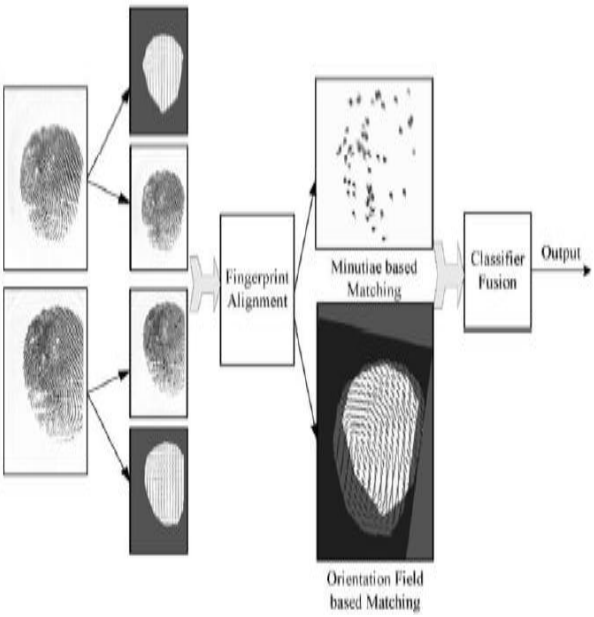

Fig 7. Flow chart showing the hybrid technique

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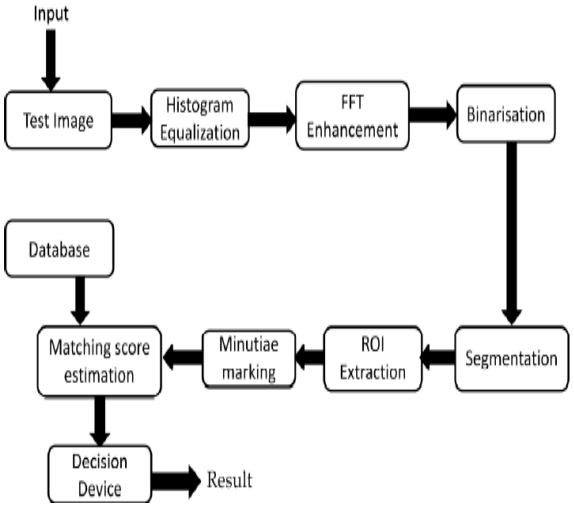

Fig 8. Block Diagram of Hybrid Technique Combining Local and Global features

The block diagram shown in the Fig 8. Shows the different steps involved in the proposed technique. The fingerprint was acquired using the optical scanner which was taken as the test image. The database used here is the standard database FVC 2000 and FVC 2002.

Then the histogram equalization of the test image is obained followed by the FFT (Fast Fourier Transform) to obtain the enhanced test image. Now the gray scale image so obtained is converted to the binarised image [3]. The orientation field estimate is then obtained by the segmentation process which also removes the noise. Since on a ridge or valley, the intensity of image is expected to be closer to each other, thus the corresponding direction is assigned to that image point. Thus the directional field [1, 2 and 3] and singular points are obtained which is shown in Fig 9.

Now the region of interest [2], is extracted from which the minutiae points can be marked. These can then be compared with the training vectors stored in the database to obtain the matching score. And then the final decision is made to obtain the final result.

Fig 9. Shows the Directional field (triangle), core point (big circle –indicating center pixel), singular field and the minutiae points (small circles).

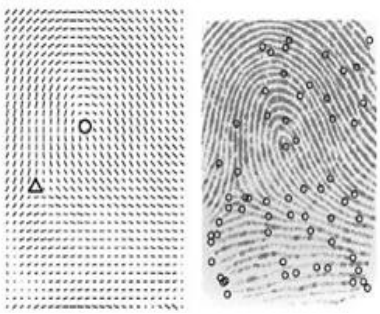

Fig 9. Fingerprint with singular point, directional field (triangle) and minutiae (small circles)

V. RESULT ANALYSIS

The results obtained in each step are given as follows-:

Step 1- The database taken here is FVC 2000 and FVC 2002.

Step 2-The test fingerprint image is obtained from the optical scanner as shown in Fig 10.

Fig 10. Test Image

Step 3-The histogram equalized image shown in Fig 11. is obtained which expands the gray level distribution of the image which thus enhances the perceived information from the image.

Fig 11. Histogram equalized image

Step 4-The enhanced image as in Fig 12. After FFT transformation is further improved as some falsely broken points on ridges are connected and some spurious connections between ridges are removed. Thus a better quality image is obtained.

Fig 12. FFT enhanced image

Step 5-Binarization process [10] is used to transform gray scale image into single bit binarized image where one value holds for valleys and zero for ridges [1,3].Thus the binarized image is black and white image as seen in Fig 13.

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Fig 13. Binarized Image

Step 6-The thinned image is then obtained which reduces the binarized image to the strokes of one pixel width which can be seen in Fig 14.

Fig 14. Thinned Image

Step 7- The segmented image is obtained using the orientation field estimate which gives the direction of orientation at each point of image as in Fig 15.

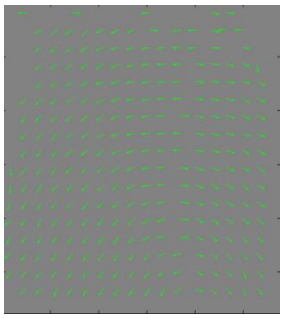

Fig 15. Orientation field estimation using segmentation

Step 8-The ROI (Region of Interest) is obtained which is visible in Fig 16. This gives the effective area which consists of effective ridges and furrows free from the confusion created by the spurious minutiae.

Fig 16. Extracted ROI (Region of Interest)

Step 9- Minutiae points are then marked by using window technique which can then be used for recognition purpose. These minutiae points can be seen in Fig 17.

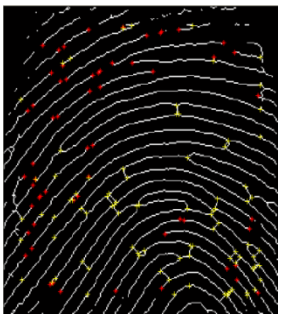

Fig 17. Extracted Minutiae points

Step 10- The matching score is then evaluated by comparing the test and the training vectors.

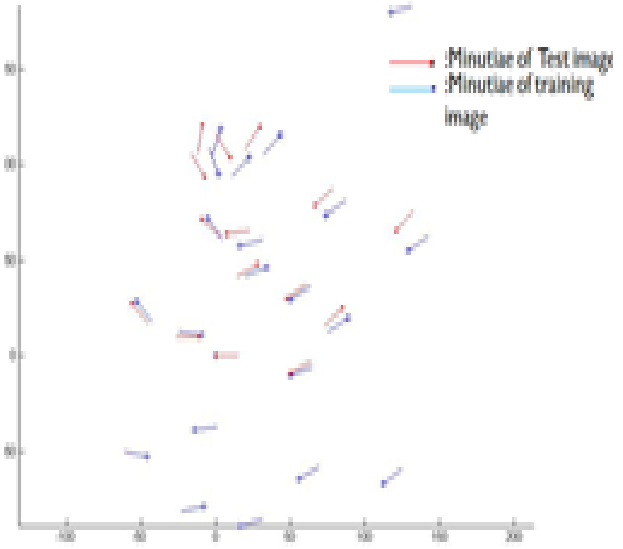

Fig 18. Graph showing the plot of training and test vectors

The matching score obtained = 0.77067 by comparing the test and training sets which is visible in the Fig 18. Thus the match of the test image is present in the database.

VI. CONCLUSION

Initially Minutiae based technique was used for obtaining a match between the training and test image. This technique takes into consideration the local features like termination and bifurcation for obtaining the matching score. But this technique does not work well in the presence of noise; large displacement etc. as minutiae being a local feature is adversely affected by the above mentioned factors. Hence we have also incorporated the global features in our study to obtain better results. Thus a combination of local cues and global structures is used for the purpose of fingerprint recognition. Using this hybrid technique leads to inclusion of additional feature i.e. orientation field estimate in our study which helps in achieving better results especially for the poor quality images .Thus when by using this hybrid technique fingerprint matching was done. The test image was matched against the training set to obtain the similarity scores. In our study we achieved a matching score of

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0.7706 we indicates that a match was present in the database. Thus the hybrid technique used provides more accurate results by incorporating orientation field as an additional feature.

In future, more works can be done by incorporating some other local and global features. We can also use other non-linear techniques such as neural networks to obtain more efficient matching results.

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BIOGRAPHY

Niharika Modi was born in 1992.She is presently pursuing her B.Tech degree in Silicon Institute of Technology, Bhubaneswar. Her areas of interest are image processing, computer vision and biometrics.