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Implementation of Fingerprint Recognition System using Minutiae Score Matching

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Abstract*: *In this computerized world, the prominent biometric technique used to recognise a person is known as fingerprint. A systematic combination of ridges, whorls and furrows in the outer layer of finger is known as fingerprint. Fingerprints vary from person to person but permanent. The aim of this paper is to establish fingerprint identification system that is based on the method called minutiae score matching. The process of the system includes image enhancement, binarization, thinning, minutiae score extraction. Image enhancement and binarization techniques are applied on fingerprint image to get good minutiae points. Thinning is used to convert image to one pixel width . Extract the minutiae points from thinned image. Using these points, find the real minutiae points. No match is perfect in both verification and identification. Therefore, biometric systems are designed to check whether match is found or not, based on a threshold value which is a predefined number. The score that is generated by using real minutiae points is compared to threshold value to found a match or no-match.

Index Terms*: *image enhancement, binarization, thinning, minutiae score extraction.

I. INTRODUCTION

Biometric systems are used to recognize a person in two ways. They are behavioral and physiological characteristics. The behavioral characteristics are keystroke, signature, speech these features change according to age but physiological features such as fingerprint, face does not change throughout the entire life. Fingerprint consists of ridges and whorls on the uppermost layer of finger. In olden days fingerprints are captured using inked impression on a paper which will be very difficult to identify and verify whose fingerprint it is because the ink many not spread evenly on the surface of the finger. So we use fingerprint scanners for scanning the fingerprint in these days. Based on the resolution of the fingerprint scanner and placement of finger on the scanner, the minutiae points vary. A good fingerprint contains 20 to 70 minutiae points approximately. The minutiae points vary from finger with scars to the same finger without scars. Fingerprint Recognition includes image enhancement, binarization, thinning, minutiae extraction, minutiae matching and generate match score [1].

II. LITERATURE SURVEY

Ravi.J. et al [2] proposed Fingerprint recognition using minutia score matching to find out the matching percentage using preprocessing and post-processing techniques. L.Lam et al [3] proposed the process of thinning and also discussed the requirements of good thinning algorithm. Duoqian Maio et al [4] used principal graph algorithm by kegl to obtain principal curves for auto fingerprint identification system. Bhupesh Gour et al [5] proposed a new method for calculating the minutiae from finger prints. Jain.A.K, Prabhakar S et al [6] has developed a new finger print identification technique by using filter based representation.

III. DEFINITIONS

A. Termination: Ending part of a ridge is known as termination

B. Bifurcation: The place where a single ridge is divided into 2 separate ridges is called bifurcation

C. Binarization: Conversion of gray scale image to black and white is known as Binarization

D. Thinning: Reducing the ridges of image pixels to one pixel width

IV. RESEARCH METHODOLOGY

Fingerprint Recognition system composed of fingerprint sensor, minutiae extractor and minutiae sensor represented in Figure 1.

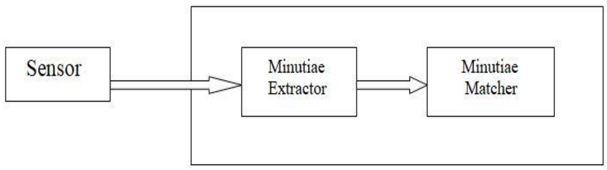

Fig 1: Fingerprint recognition approach.

There are 3 stages for implementing minutiae extractor and represented in Figure 2. They are preprocessing, minutiae extraction and post-processing.

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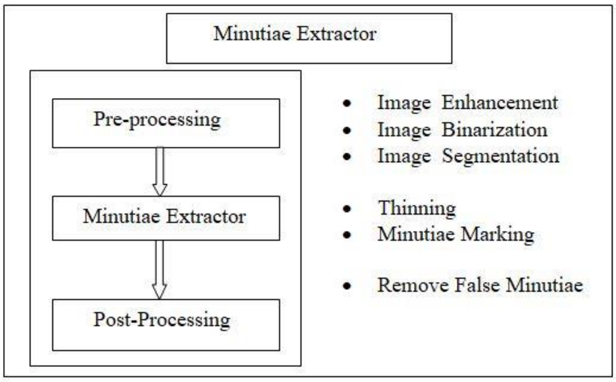

Fig 2: Minutiae Extractor.

Pre processing:

A. Image Enhancement :

The fingerprint image that is obtained from the fingerprint scanner may be poor in quality. So image enhancement is used to form an image clearer which will be helpful for further process. There are two techniques for image enhancement. They are Histogram Equalization and Fast Fourier Transform [7].

Histogram Equalization :

To increase the perceptional information histogram equalization help us to expand the pixel value. histogram equalization represented in following figure 3.

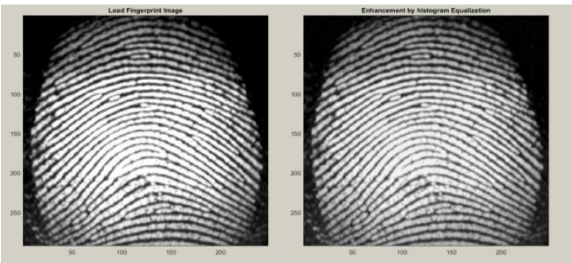

Fig 3: Histogram Equalization.

Fast Fourier Transformation :

In FFT the given image is further divided into small blocks with size (32 x 32) and perform FFT as below

$$f(a,b) = \sum_{x=0}^{m-1}\sum_{y=0}^{n-1} f(x,y) * \exp\{-j2\pi * \left(\frac{ax}{m} + \frac{by}{n}\right)\} \quad (1)$$

For a=0,1,2,3………..31, b=0,1,2,3,…....31.

To enhance a particular block we need to multiply the

FFTby its magnitude set of times.

Therefore magnitude of the original image is

FFT=abs (f (a,b))=|f(a,b)|.

We get the enhanced block as below

$$g(x,y) = f^{-1}\{f(a,b) * |f(a,b)|^K\} \quad \textbf{(2)}$$

Where f^{-1}(f(a,b)) is changed to

$$f(x,y) = \frac{1}{mn}\sum_{x=0}^{m-1}\sum_{y=0}^{n-1} f(a,b) * \exp\{j2\pi * \left(\frac{ax}{m} + \frac{by}{n}\right)\} \quad (3)$$

For x=0,1,2,3………..31, y=0,1,2,3,…....31.

The K in formula (2) is constant that is K=0.45. If K is too high there will be a chance of getting false joining in ridges, So termination lead to bifurcation.

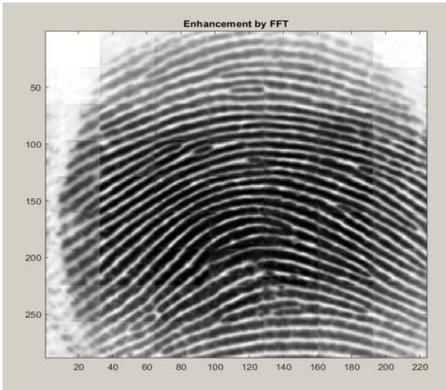

Fig 4 : Fingerprint Enhancement by FFT.

B. Image Binarization:

Binarization is a process used to convert gray scale pixel image(0-255) to binary image that is black and white image(0-1). Hence a binary image is created by colouring each pixel with either black or white(white for 1 and black for 0). The problem raised during binarization is all fingerprints do not have same characteristics.

Hence the adaptive binarization technique in figure 5 is used for binarization of fingerprint images. In adaptive binarization the image is further divided into 16x16 blocks. For each block the mean intensity value is calculated and then each pixel value is changed to one if intensity value is greater than mean intensity value otherwise 0.

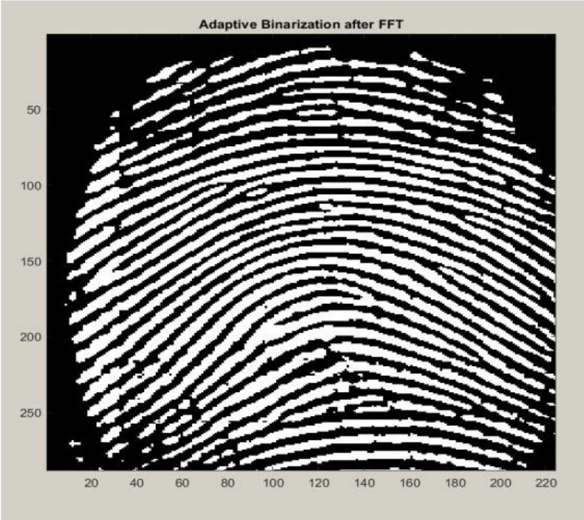

Fig 5: Adaptive binarization.

C. Image Segmentation:

In image segmentation the ridges that are not effective are removed because it may have noise. In the entire fingerprint image only small portion of the image is necessary so we need to find the region of interest (ROI) in figure 6 and 7. There are two steps in extracting the ROI. They are block direction estimation and direction variety check.

Block direction estimation:

For every block in the fingerprint image with 16x16 size we need to estimate block direction. The used is as follows:

1) For each pixel in the block along x-axis(v_x) and y-axis(v_y) calculate gradient values.

2) The least square approximation is calculated using following formula.

$$tan2\alpha = 2\sum\sum(v_x * v_y)/\sum\sum(v_x^2 - v_y^2)$$

We can also replace tangent value with sine and cosine values because it is easy to understand

$$\tan 2\alpha = 2\sin\alpha\cos\alpha/(\cos^2\alpha - \sin^2\alpha)$$

The blocks without ridges are removed after block direction estimation by using the below formula

$$A = \{2\sum\sum(v_x * v_y) + \sum\sum(v_x^2 - v_y^2)\}/W * W * \sum\sum(v_x^2 + v_y^2)$$

If the certainty level that is A for each block is below the threshold then it is considered as background block.

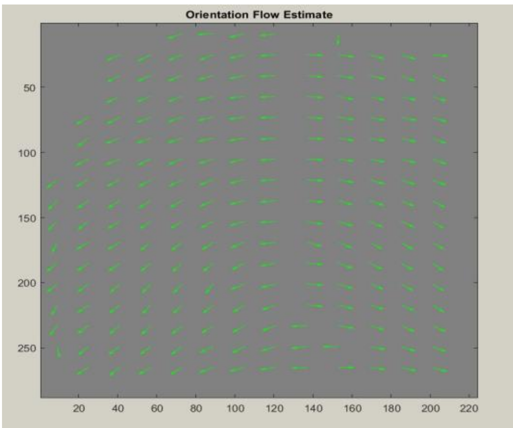

Fig 6: Orientation flow estimate.

ROI extraction:

In this ROI extraction we use two operations. The 'OPEN' operation is used to expand images. The 'CLOSE' operation is used to minimize the image.

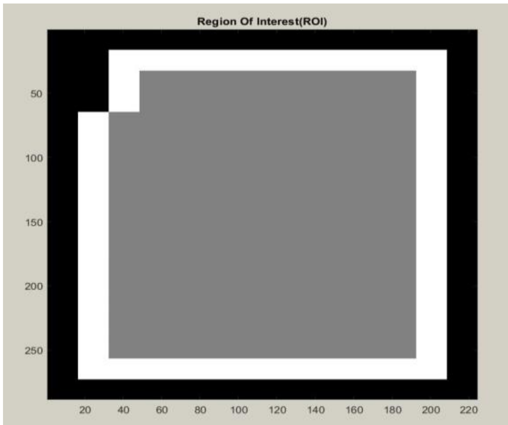

Fig 7: Region of interest(ROI).

Minutiae Extraction:

A. Thinning:

Thinning is used to reduce the image pixels to width of one pixel. For thinning process the iterative parallel thinning algorithm[8] [9] is used. In this the deletion of individual pixel is based on the result of previous iteration. So the nth iteration depends on (n-1) iterations. Hence all the pixels can be processed at the same time. Then by using the morphological operations remove H-breaks and spikes. The total process is represented in figures 8, 9, 10 and 11.

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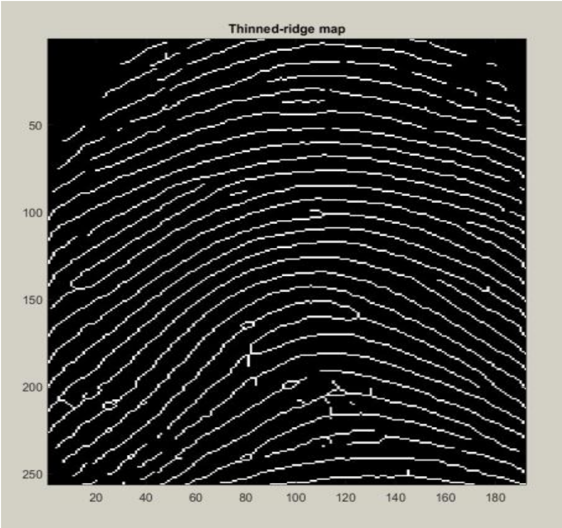


Fig 8: Thinned-ridge map.

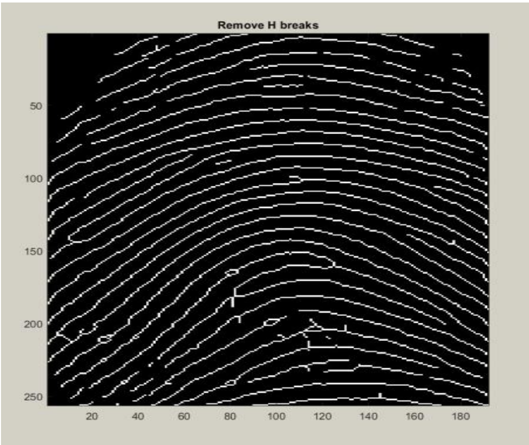


Fig 9: Remove H breaks.

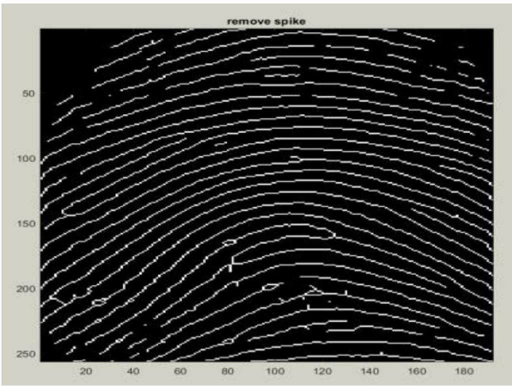
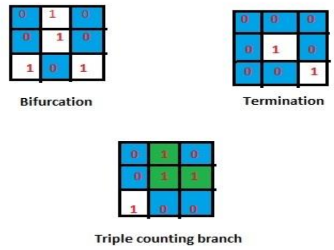


Fig 10: Remove spikes.

B. Minutiae Marking:

The minutiae extraction is based on the concept of crossing number(CN). In a 3x3 window, for bifurcation centre pixel should be 1 and also should have 3 neighbours with value 1.For termination the centre pixel should be 1 and should have one neighbour with value 1.For triple count branch the uppermost, rightmost pixel should be 1 and for both there should be another neighbour outside with value 1 and also centre pixel should be 1 these are treated as two branches but triple count branching has only one branch is there in that region .So neighbours of the branch that are not having branches are only added.



In this we find average of inter-ridge width that is 'd'. The average distance between two neighbouring ridges is called as inter ridge width. The row of a thinned ridge image is scanned and add all pixels whose values are 1 in a row. Now divide the length of the row by the above addition to get d. To increase the accuracy we need to perform such scanning upon several rows and columns. Finally all the inter-ridge width is averaged.

Along with the minutiae marking[4], the ridges that are thinned are labelled with a unique id as it will be helpful for further operations.

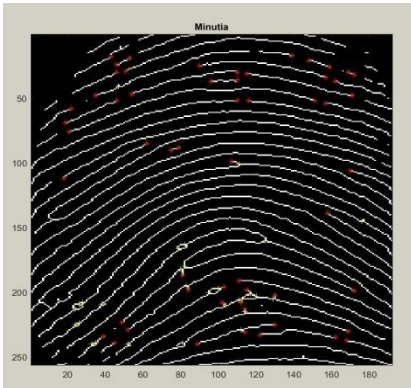


Fig 11: Minutiae marking.

Post-Processing:

A. False minutiae removal:

Only some of the minutiae points that are acquired in the previous stage are real because they may contain false ridge breaks. The false minutiae points will reduce the accuracy of matching. So we use some techniques for removing false minutiae. There are seven types of false minutiae that are identified and as shown below in figure 12.

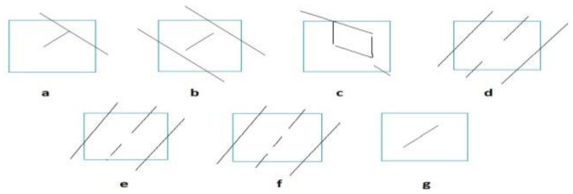


Fig 12: False minutiae structures.

The following are identified and removed

1) The distance between one ridge ending and one valley is calculated and compared with d. If it is less than d and the both minutiae belong to same ridge (a) then remove them.

2) The distance between two valleys are calculated. if it is less than d and they belong to same ridge then remove those two valleys (b, c).

3) Even though the directions are coinciding with minimum change in angle and the both ridges are ending with distance d then the two ridge endings are treated as false minutiae and are removed (d, e, f).

4) If distance between two ridge endings are less than d remove them(g).

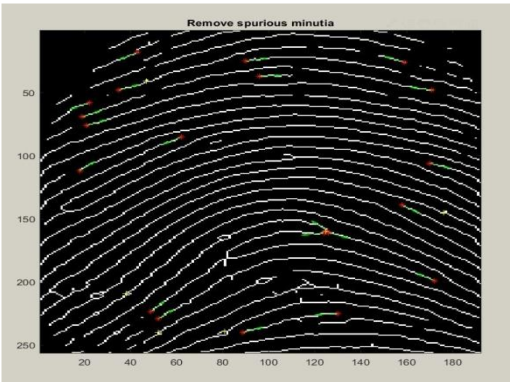


Fig 13: Remove spurious minutiae.

B. Minutiae Match:

Take 2 pairs of minutia. Using this minutia match algorithm. It checks whether 2 minutiae pairs belong to same finger or not. It consists of 2 phases.

Alignment stage:

Choose one minutia from each image that are needed to be matched and calculate similarity between the two ridges. If resemblance is greater than threshold, transform minutia to new system whose origin is at the reference point and whose x-axis coincides with the direction of referenced point.

Match stage:

After getting the changed minutiae points. We need to count the matched minutiae pairs using elastic match algorithm and we need to assume that those two minutiae are in the same direction and position. Calculation of final match percentage[6] of 2 fingerprints is as follows

$$match\ percentage = \frac{total\ number\ of\ matched\ pairs}{number\ of\ minutiae\ marked\ in\ fingerprint} * 100$$

If the percentage is greater than threshold value then the choosen two fingerprints belong to same finger.

V. FUTURE WORK

The Fingerprint recognition system that we have developed using minutia score matching gives us accurate output. The future work proposed for this is to develop an application for fingerprint recognition which will be helpful for opening the locker door or house door whenever the match is found.

VI. CONCLUSION

In this paper we proposed fingerprint recognition system using minutia score matching method. After performing all the pre-processing and post-processing methods we can find whether the given two input fingerprint images are of same finger or not. In future we can improve this method for getting more accuracy.

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