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MINUTIAE BASED FINGERPRINT IDENTIFICATION

DHOLE S.A.[1]* AND PATIL V.H.[2]

[1]Bhatati Vidyapeeth (Deemed Univ.) Pune, MS, India.
[2]Matosree College of Engg. & Research Center, Nashik, MS, India.
*Corresponding Author: Email- sampadadhole@rediffmail.com

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Abstract- Fingerprints are the most widely used biometric feature for person identification and verification in the field of biometric identification. This paper presents the implementation of a minutiae based approach to fingerprint identification and verification. The technique used in this paper is based on the extraction of minutiae from the thinned, binarized and segmented version of a fingerprint image. Minutiae mean ridge endings & ridge bifurcation points of ridges. The results are tested on FVC 2002 database. The results shows that experiments gives approximately 90% accuracy.
Keywords- Histogram equalization, image enhancement, image segmentation, Minutiae points , thinning.

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Introduction

In the era of Information Technology, openness of the information is a major concern. As the confidentiality and integrity of the information is critically important, it has to be secured from unauthorized access. Security refers to prohibit some unauthorized persons from some important data or from some precious assets. So we need accurate, automatic personal identification in various applications such as ATM, driving license, passports, citizen's card, cellular telephones, voter's ID card etc. In addition to identification, security is equally important. The past methods of identification such as PIN, passwords etc. are unreliable, since there is possibility of frauds. Solution to such problem is given by using biometric identities.
Biometric is Physiological (e.g., fingerprints, face, iris) and behavioral (e.g., speech) characteristics of person which is absolutely unique to him.. Biometrics identifies the person by what the person is rather than what the person carries, unlike the conventional authorization systems like smart cards. Biometric identifiers cannot be misplaced, forgotten, guessed, or easily forged. Among all biometrics Fingerprint is most likely used. Fingerprints possess two main types of features that are used for automatic fingerprint identification and verification (i) Global ridge and furrow structure that forms a special pattern in the central region of the fingerprints and (ii) Minutiae details associated with the local ridge and furrow structure. Minutiae means ridge endings & ridge bifurcations.

- Ridge ending - the abrupt end of a ridge
- Ridge bifurcation - a single ridge that divides into two ridges.

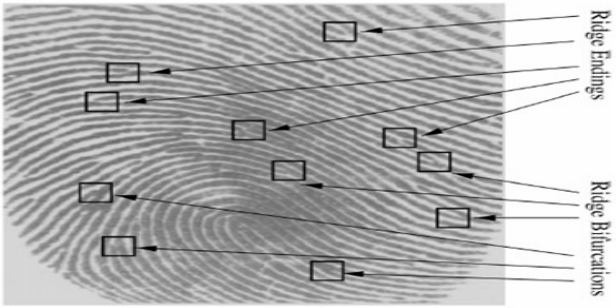

Fig. 1- Minutiae points

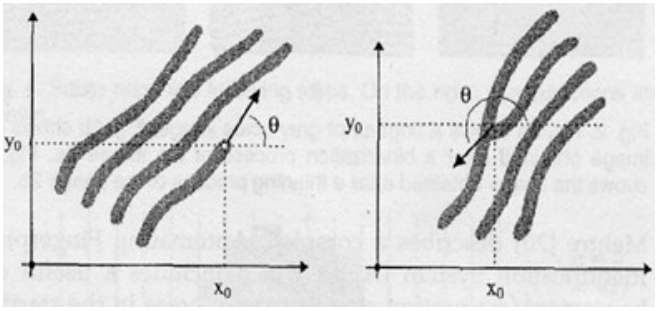

Fig. 2- Ridge endings, Ridge Bifurcation

An overview of the method

In enrollment module features are extracted & stored in database. In Authentication module features are extracted & match with the database feature. Depending on matching score result displayed (yes/no).

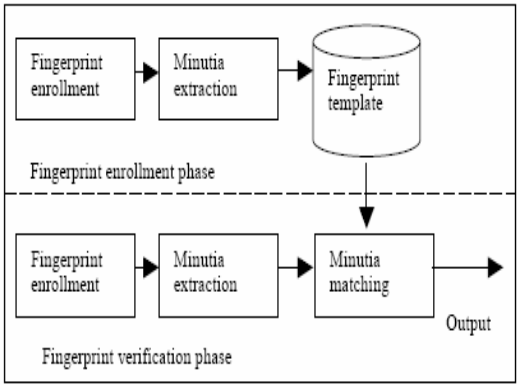

Fig. 3- Fingerprint Identification system

The Major steps involved in automated fingerprint recognition include

a) Fingerprint Acquisition
b) Feature Extraction-which includes Image enhancement, Image thinning, Image segmentation, Minutiae Extraction
c) Matching

The following section gives the description of the steps followed in this project for extraction of the actual minutiae in enrollment module.

Fingerprint Acquisition

Fingerprint acquisition can either be offline (inked) or online (Live scan). In the inked method an imprint of an inked finger is first obtained on a paper, which is then scanned.

This method usually produce images of very poor quality because of the non-uniform spread of ink and is therefore not exercised in online AFIS. For online fingerprint image acquition, capacitive or optical fingerprint scanners such as URU 4000, etc. are utilized which make use of techniques such as frustrated total internal reflection (FTIR), ultrasound total internal reflection, sensing of differential capacitance and non contact 3D scanning for image development.

Live scan scanners offer much greater image quality, usually a resolution of 512 dpi, which results in superior reliability during matching in comparison to inked fingerprints.

Pre-processing

Pre-processing involved, image enhancement, thresholding, image segmentation, thinning.

Image Enhancement

Image enhancement reduces image to show only to show its edge details. For good quality fingerprint feature extraction is much easier, efficient & reliable in comparison to a relatively lower quality fingerprint. The quality of fingerprint is degraded by skin condition (e.g. wet or dry, cuts & bruiser), sensor noise, non-uniform contact with sensor surface & inherently low quality fingerprint images (e.g. those of elderly people, laborers). A significant percentage of fingerprint are of poor quality, which must be enhanced for recognition process to be effective

There are two major objectives of fingerprint enhancement is

1) to increase contrast between ridges & valleys
2) to connect broken edges

This objective can be fulfilled by using histogram equalization technique which improves the global contrast of an image by adjusting the intensity distribution on a histogram. This allows areas of lower local contrast to gain a higher contrast without affecting the global contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. So after histogram equalization gray scales occupies all ranges from 0 to 255.

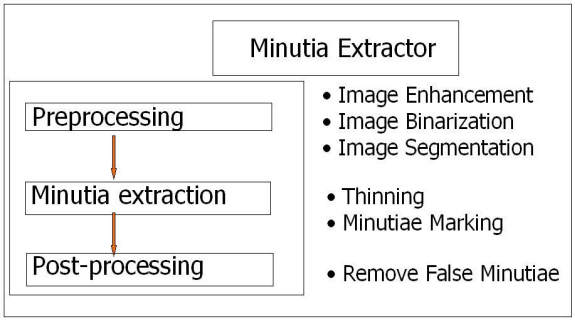

Fig. 4- Minutiae Extractor

Fig. 5 (a)- Original Image **(b)-** Enhanced Image after histogram equalization

Thresholding

It is used to convert gray level image to binary image. It is a process which transforms the 8-bit Gray image to a 1-bit image with 0 -value for ridges and 1-value for furrows.

A locally adaptive binarization method is used to binarize the fingerprint image. In this method image is divided into blocks of 16 x 16 pixels. A pixel value is then set to 1 if its value is larger than the

mean intensity value of the current block to which the pixel.

Fig. 6 - After Binarization

Fingerprint Image Segmentation

To extract the region of interest(ROI), two steps are used

- Block direction estimation and
- ROI extraction by Morphological methods.

a) Block direction estimation

Here the fingerprint image is divided into blocks of size 16 x 16 pixels (W x W) after which the block direction of each block is calculated according to the algorithm:

- Calculate the gradient values along x-direction (gx) and y-direction (gy) for each pixel of the block. Two Sobel filters are used to get gradient of x & y axis.
- For each block, use following formula to get the Least Square approximation of the block direction. for all the pixels in each block.

$$\tan 2\beta = \frac{2\sum\sum(g_x * g_y)}{\sum\sum(g_x^2 - g_y^2)}$$

- After calculating estimation of each block direction, those blocks without significant information on ridges and furrows are discarded based on the following formulas:

$$E = \frac{2\sum\sum(g_x * g_y) + \sum\sum(g_x^2 - g_y^2)}{W * W * \sum\sum(g_x^2 + g_y^2)}$$

For each block, if its certainty level E is below a threshold, then the block is regarded as a background block.

b) ROI Extraction

For ROI extraction two Morphological operations OPEN and CLOSE is used. The OPEN operation can expand images and remove peaks introduced by background noise The 'CLOSE' operation can shrink images and eliminate small variations.

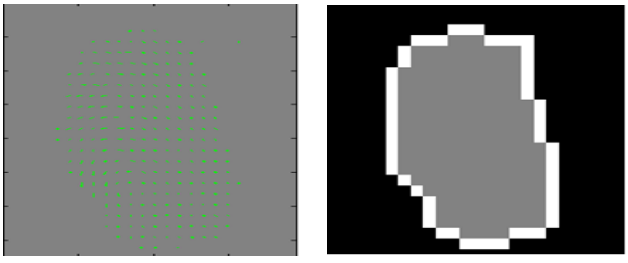

Fig. 7 (a)- Directional Ridge map **(b)-** ROI of image

Thinning

In order to reduce to single pixel width of ridges in binary image thinning is used. These operations are necessary to simplify subsequent structural analysis of image for extraction of fingerprint minutiae. Thinning must be performed without modifying original ridge structure of image. During this process, algorithm cannot miscalculate beginning; endings & bifurcations of ridges neither ridges can be broken. MATLAB function thin is used to get single pixel width. To remove the spikes, check to M-connectivity, so that unwanted pixels are removed.

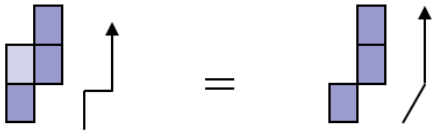

Fig. 8 (a)- Before M-connectivity **(b)-** After M-connectivity

Fig. 9 (a)- Ridge thinned Map **(b)-** After removing spikes

Minutiae Marking

Minutiae mean ridge endings & ridge bifurcation points. The pixel which has two or more than two neighbors are called as ridge bifurcations. The pixel which has only one neighbor is called ridge ending.

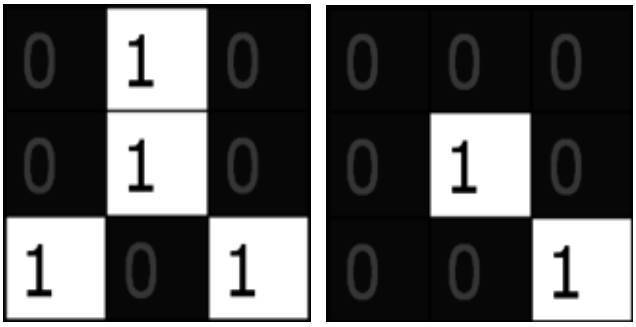

Fig. 10 (a)- Ridge bifurcation **(b)-** Ridge Ending

False Minutiae Removal

False ridge breaks due to insufficient amount of ink & ridge cross connections due to over inking are not totally eliminated. So to keep the recognition system consistent these false minutiae need to be remove.

- If distance between one bifurcation & one termination is less than D & two minutiae in same ridge, remove both of them, where D is average distance between two parallel neighboring ridges.
- If distance between two bifurcation is less than D &they are in same ridge, remove the two bifurcations.
- If two terminations are within a distance D & their directions are coincident with a small angle variation & no any other

termination is located between the two terminations then remove both of them.

- If two terminations are located in short ridge with length less than D, remove the two terminations.

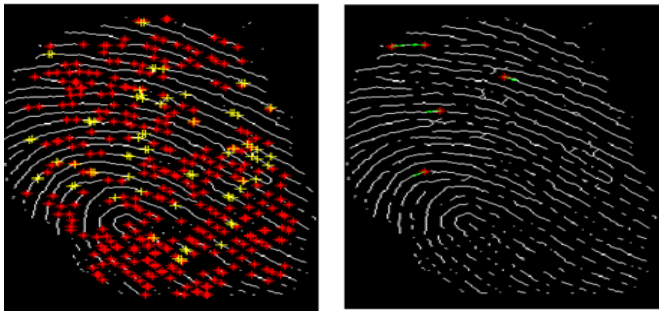

Fig. 11 (a)- Minutiae points **(b)-** Real Minutiae point

Minutiae Matching

The process of fingerprint matching involves comparing a query image with a set of one or more template images. The query and template features are matched to generate matching scores we perform Minutiae Matching to check whether they belong to the same person or not. For matching Euclidean distance is used. if the Euclidean distance (Ed) between them is smaller than a given tolerance d0 and the direction difference (dd) between them is smaller than an angular tolerance θ_0.

$$Ed = \sqrt{(xi - xj)^2 + (yi - yj)^2} \leq d0$$

$$dd = \min\ (|\theta i - \theta j|, 360 - |\theta i - \theta j|) \leq 0$$

Now the total number of matched minutiae pair is calculated to generate match score. If match score is greater than 90%, the current minutiae are belong to the same person. The result gives the person matched with database image. Otherwise result is match not found.

Experimental Results

The results are tested on FVC 2002 database. This database contains four distinct databases DB1_A, DB2_A DB3_A DB4_A The results shows that experiments gives approximately 90% accuracy

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