International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-1 Issue-6, August 2012

An Improved binarization based algorithm using minutiae approach for Fingerprint Identification

S. M Rajbhoj, P. B. Mane

Abstract - ***The long history of fingerprint, their extensive use in forensics and with need of automatic personal identification in recent years, fingerprints is receiving a lot of attention. There is misconception that fingerprint identification is a fully solved problem. However numerous fingerprint systems currently available which use minutiae based approach still do not meet performance requirement of several civilian applications. Performance of these systems degrades with deterioration in the quality of fingerprint image. In absence of an a priori enhancement step most of the binarization based techniques do not provide satisfactory results when applied to low quality images. Thus trying to eliminate these shortcomings we present an improved approach for fingerprint recognition providing accurate automatic personal identification. In this approach we use optical sensor which captures image of excellent quality with large capture area and superior reliability. The recognition algorithm first use histogram equalization technique to improve the global contrast of an image, then enhancement of the image is done by an efficient enhancement technique. We then use binarization based method to extract minutiae. False minutiae are removed using thresholding technique. The matching is based on determining the total number of matched minutiae based on Euclidian distances. This system is tested on two different databases. The experimental result shows that incorporating a fast enhancement technique and using an optical scanner increase the accuracy of the system for lower values of False accept rate.***

Keyword - ***Fingerprint identification, Minutiae, Enhancement, Binarzation, Extraction, Thresholding, Euclidian distances.***

I. INTRODUCTION

Biometric recognition, or simply biometrics, refers to the automatic recognition of individuals based on their physiological and/or behavioral characteristics. Some of the physiological and/or behavioral characteristics associated with individuals are fingerprint, face, iris, hand geometry, signature, voice, palm print, etc [1]. Fingerprint is the ridges and furrow pattern on tip of the finger which have been used extensively for personal identification of people. A fingerprint is believed to be unique to each person (and each finger). Fingerprints of even identical twins are different. Due to this reason fingerprints are one of the most widely used biometric technologies. There are basically two forms of representations for fingerprints based on local features and global features [2]. Typically global features are ridge structures which are used to determine the class of fingerprint, while the distribution of minutiae points is used to match and establish the similarity between fingerprints. Hence minutiae based approach [3][4] which represents the fingerprint by its local features (like terminations and bifurcations), is widely used in commercially available automatic fingerprint identification systems (AFIS). This minutiae information which is the local feature may not be very discriminative in case of solid state sensors which usually capture only a small area of fingertip. Multiple impression of same finger taken at different instances may overlap due to translation and rotational of subsequent fingerprints, in such situations due to lack of sufficient number of common minutiae points minutiae based systems will not perform well. Also in case of poor quality images it is difficult to accurately locate minutiae points [5]. Hence to overcome these difficulties encountered in fingerprint identification system we present improved approach for minutiae fingerprint recognition. In this approach we capture fingerprint image using optical sensor so as to get sufficient discriminative information (typically we can extract 40 minutiae compared to 25 minutiae in case of solid state sensor). Secondly performance of systems is affected by poor quality of images due to various reasons such as variation in impression, skin condition, and non co operative subjects. This result in number of spurious minutiae or genuine minutiae may get ignored and error may be introduced in locating minutiae. So to enhance the quality of input image we have incorporated an efficient enhancement technique which improve the clarity of ridge and furrow structure based on local ridge orientation and local frequency.

Section 2 describes the proposed system in detail. Section 3 describes the experiment conducted to evaluate the performance of the proposed system and Section 4 summarizes the paper.

II. THE PROPOSED FINGERPRINT SYSTEM

The Algorithm of proposed fingerprint system is as shown in figure 1. The first stage of the system consists of fingerprint sensor which captures the fingerprint image. In second stage the fingerprint image provided by the sensor is first processed and then features are extracted. The third stage is a matching algorithm that produces the matching score to which an acceptance threshold is applied to make final decision. The following section gives the detailed description of the various modules of the system.

A. Fingerprint Sensor

We have used U.are.U 4500 Fingerprint Reader [6] as

Manuscript published on 30 August 2012.
***** Correspondence Author (s)
S. M. Rajbhoj*, Electronics Dept, Bharati Vidyapeeth Deemed University, Pune, M.S, India.
Dr. P. B. Mane, Principal, AISSMS IOIT, Pune, M.S. India,

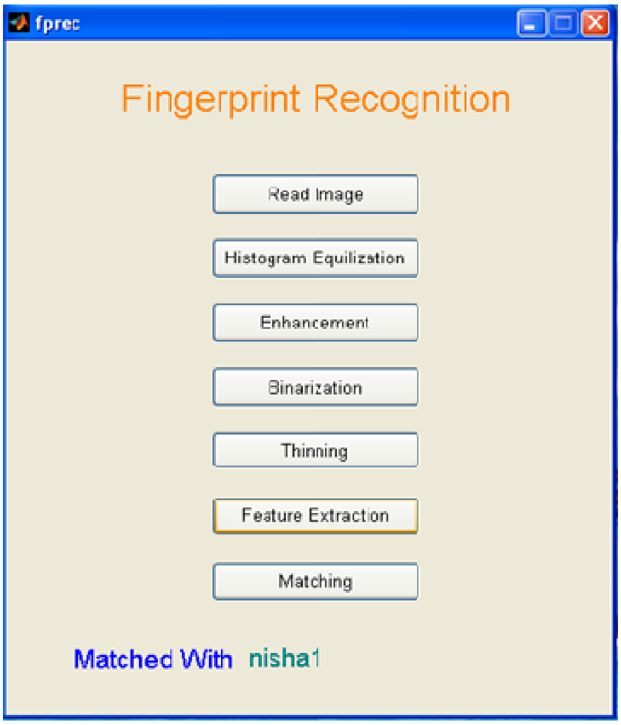

Figure 1. Algorithm of Proposed System.

fingerprint sensor designed by Digital Persona. By placing the finger on the glowing reader window, we can quickly and automatically scan the fingerprint. On-board electronics calibrate the reader and encrypt the scanned data before sending it over the USB interface. This fingerprint reader has a excellent image quality [512 DPI], a large capture area [14.6 x 18.1] and superior reliability. Optical sensors are made of a LED light source and a CCD placed on the side of glass platen on which fingerprint is placed. The LED illuminates the fingerprint and CCD captures the light reflected from the glass enhancing the pattern of the fingerprint.

B. Histogram Equalization

The global contrast of an image is improved by adjusting the intensity distribution in 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. The histogram after the histogram equalization occupies all the range from 0 to 255 and the visualization effect is enhanced. Figure 2 shows input fingerprint image and output after Histogram Equalization

Figure. 2 Output after Histogram Equalization.

C. Fingerprint Enhancement

The performance of any fingerprint system relies heavily on the quality of the input fingerprint images. However, in practice, due to variations in impression strength, ridge conditions, skin conditions and acquisition devices etc. a significant percentage of acquired fingerprint images are of poor quality, so to improve the clarity and to facilitate the extraction of the characteristics, the image acquired from the optical sensor the image is first enhanced. A fingerprint enhancement algorithm applies a set of intermediate steps on the input image. Firstly input image is normalized so that it has a pre-specific mean and variance. Normalization does not change the clarity of image; it just reduces the variations in grey level values along ridges and furrows, which facilitates the subsequent processing steps. Then local ridge orientation is computed which defines invariant coordinates for ridges and furrows. In local neighborhood where no minutiae points appear, the grey levels along ridges and furrows can be modeled as a sinusoidal-shaped wave along a direction normal to the local ridge orientation, so we estimate the ridge frequency image. To efficiently remove the undesired noise and preserve the true ridge and furrow structures, Gabor filters are used which have both frequency selective and orientation selective properties and after filtering we get the enhanced image [7]. The term segmentation here is generally used to denote the separation of fingerprint area (foreground) from the image background. Separating the background is useful to avoid extraction of shaped plane wave with a well defined frequency and orientation, whereas background regions which are characterized by very little structure do not have the relevant information.

D. Binarization

Local adaptive thresholding method is used to binarize the image[8]. In this process we transform the 8-bit Gray image to a 1-bit image with 0-value for ridges and 1-value for furrows. After the operation, ridges in the fingerprint are highlighted with black color while furrows are white. In this locally adaptive method, image is divided into blocks of 32 x 32 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 belongs. Figure 3 shows output after Enhancement and after binarization.

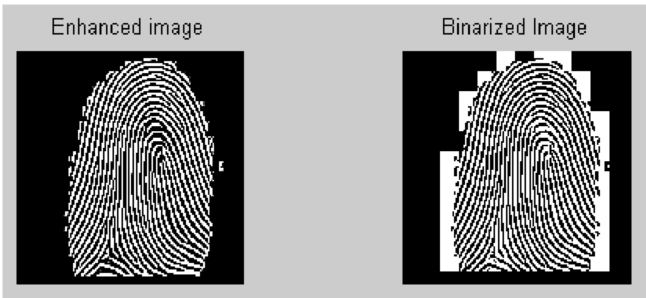

Figure. 3 Output after Image Enhancement and after Image binarization

E. Ridge Thinning

Here we eliminate the redundant pixels of ridges till the ridges are just one pixel wide. This is done using the MATLAB's built in morphological thinning function. Bwmorph[9]. The operation is based on following criterion not to remove ridge end points and not to break connectedness of the ridge.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

This is because for center pixel there are 8 neighbors in window, so there can be maximum of 256 combinations of criterion, whether the center pixel is delectable or not. Hence this preserves connectivity and minimizes the number of artifacts such as erroneous bifurcations. Figure 4 shows fingerprint image after Ridge thinning.

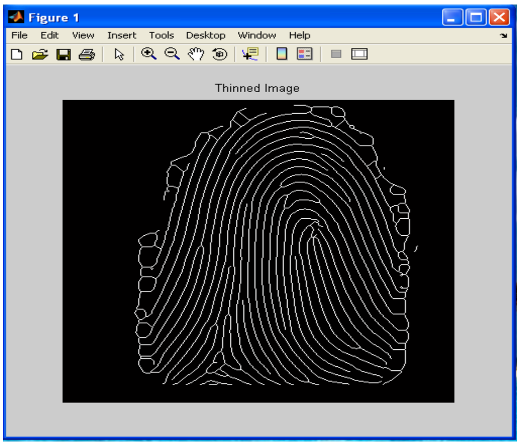

Figure 4 Output after Ridge thinning.

F. *Minutiae Extraction*

It is the process by which the minutiae points are detected in a fingerprint image. Each minutiae is characterized by its (x, y) location in the image, and the orientation θ of the ridge on which it is detected. Minutiae marking are now done using templates for each 3 x 3 pixel window as follows. If the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch (Bifurcation). If the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending (Termination). Figure 5 shows the mask for bifurcation and termination.

0	1	0
0	1	0
1	0	1

Bifurcation

0	0	0
0	1	0
0	0	1

Termination

Figure 5 Mask for bifurcation and termination

In some condition there may be false minutiae mainly due to bifurcation with short branch or two endings on a short line due to noise or two endings closely opposing is a broken ridge or endings at the boundary due to projection. Such false minutiae are removed by thresholding method. Figure 6 shows fingerprint image after extraction of minutiae.

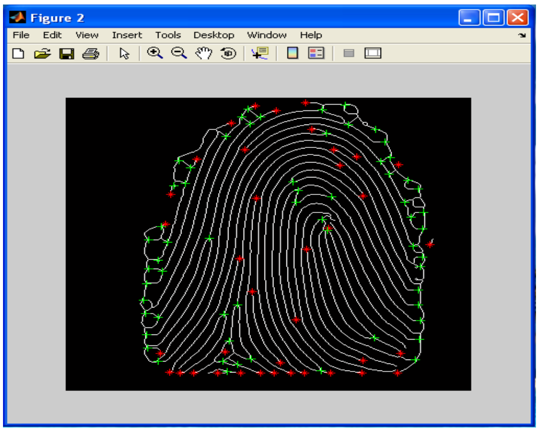

Figure 6 Fingerprint image after extraction of minutiae

G. *Minutiae Matching*

After successfully extracting the set of minutia points for all the fingerprint images in the database, we perform Minutiae Matching to check whether they belong to the same person or not .The process of fingerprint matching involves comparing the feature vectors representing minutiae points, from the template stored (T) and query image(Q). Each element of the feature vector is described by different attributes. The feature vectors in database are sorted in order and then ordered vectors are compared with feature vector of query image by finding Euclidean distance between them. The sum of the Euclidean distances is the output of the matching process that indicates the similarity of two minutiae set that are compared. This sum of the Euclidean distances is the matching score.

III. EXPERIMENTS AND RESULTS

In our experiments we have used two databases. The first was the fingerprint database created by us. These consist of fingerprint impressions obtained from 10 non habituated, cooperative subjects using U.are.U 4500 Fingerprint Reader (300x 300 images at 500 dpi). The subjects mainly consisted of students and each subject was asked to provide four good quality fingerprint impression. A set of (10x4) image was collected in this way. The second database used was the standard FVC2002 database[10]. This database consists of four databases with two sets of evaluation and training. Evaluation set is (100 x 8) and training set is (10x8). From this database we have selected training set of 10 subjects. For these subjects we selected 4 images randomly to create a set of (10x4) image which was then used as the other database.

The algorithm was implemented in MATLAB and all the images shown in above figures are simulation results. The performance of this system can be measured by getting its false accept rate (FAR) and false reject rate (FRR) at various thresholds. This error rates are brought together in receiver operating characteristics curve (ROC) that plots FAR against FRR or GAR at different thresholds [11]. FAR and GAR are computed by generating all interclass and intraclass matching scores. The interclass score is obtained when feature vectors from different individuals are compared and intraclass score is obtained, when feature vectors from same individuals are compared. The ROC curves showing the performance of the system for FVC database is shown in the Figure 6 and for our database is shown in Figure 7.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

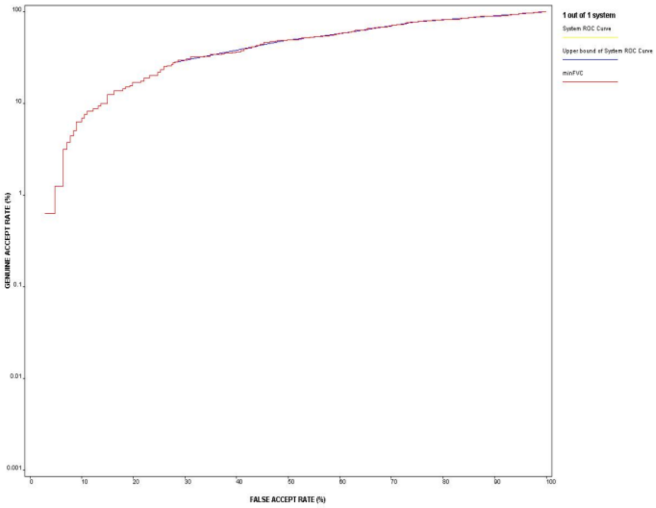

Figure 6 ROC curve for FVC Database

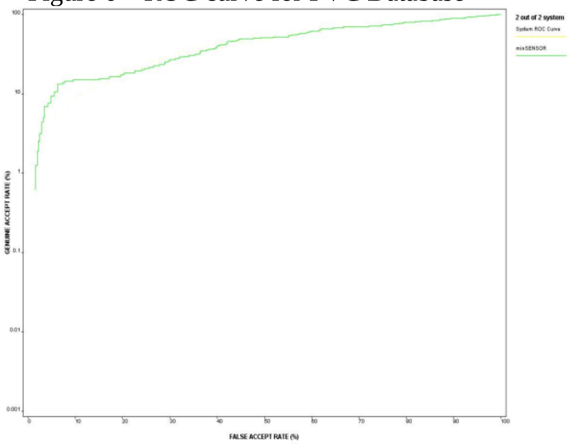

Figure 7 ROC curve for our Database

From the curve we can see that GAR has been increased for low values of FAR's and secondly we get more flat response for our database where we have acquired good quality images from an optical sensor. The extraction of minutiae takes less than 1 sec. The total time taken for fingerprint identification involving 40 templates is 0.02 sec.

IV. CONCLUSION

In this paper, an improved algorithm of minutiae based approach for fingerprint recognition providing accurate automatic personal identification has been presented. In our approach we have used optical sensor which captures image of excellent quality and helps to extract 40 to 45 minutiae in an image and hence increase the accuracy. The recognition algorithm uses histogram equalization technique to improve the global contrast of an image and a fast efficient enhancement technique before using binarization based method to extract minutiae. This overcomes the serious problem of poor quality fingerprint images. This system is tested on two different databases and Receiver Operating Characteristics (ROC) for them was plotted. The experimental result shows that that GAR has been increased for low values of False accept rates in our database as our database had good quality images. The time taken for extraction of minutiae and the total time taken for fingerprint identification was also less.

REFERENCES

[1] A. K. Jain, A. Ross, and S. Prabhakar, "An introduction to biometric recognition," IEEE Trans. on Circuits and Systems for Video Technology, vol. 14, pp. 4–20, Jan 2004.

[2] Davide Maltoni, Dario Maio, Anil Jain, and Salil Prabhakar , Handbook of Fingerprint Recognition, Springer, 2009

[3] L. O'Gorman. Fingerprint verification. In A. K. Jain, R. Bolle, and S. Pankanti, editors, Biometrics: Personal Identification in a Networked Society, pages 43–64. Kluwer Academic Publishers, 1999

[4] K. Jain, L. Hong, and R. Bolle. On-line fingerprint verification. IEEE Transactions on PAMI, 19(4):302–314, April 1997

[5] A. Ross, A. K. Jain, and J. Reisman, "A hybrid fingerprint matcher," Pattern Recognition, vol. 36, pp. 1661–1673, Jul 2003

[6] http://www.digitalpersona.com/Biometrics/Hardware-Products/U-are-U-4500-Reader/4500-Reader/

[7] L. Hong, Y. Wan, & A.K. Jain, Fingerprint Image Enhancement: Algorithm and Performance Evaluation, IEEE Transactions on Pattern Analysis and Machine Intelligence, 20(8), 1998, 777-789

[8] Ratha, Chen and A K Jain, " Adaptive flow orientation based feature extraction in fingerprint images, " Pattern Recognition, vol. 28, pp. 1657–1672, 1995

[9] Gonzales and Woods., Digital Image Processing, 3rd edition, Prentice-Hall, NJ, 2007

[10] FVC2002-Second International Fingerprint Verification Competition. http://bias.csr.unibo.it/fvc2002/download.asp

[11] Center for Identification Technology Research http://www2.citer.wvu.edu/

S. M. Rajbhoj He is graduated B. E from Shivaji University, Kolhapur in the year 1991, Post graduated in M. E. (E & TC) from COEP of Pune University in the year 2000. He is currently Pursuing PhD and working as Associate Professor in E & TC Dept. of Bharati Vidyapeeth's College of Engineering for Women Pune.

Dr. P. B. Mane He is graduated B. E from COEP of Pune and Post graduated in M. E. (E & TC) from COEP of Pune University and was awarded PhD from Bharati Vidyapeeth Deemed University Pune. He has been actively guiding UG, PG and PhD students and presently working as Principal of AISSMS IOIT, Pune.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)