A Bounding box Gabor filter-based Minutiae extraction scheme for fingerprint Recognition system

SURESHREDDY.Y.N, M.JASMINFEMINAPRIYADARSHINI.M
SCHOOL OF ELECTRICAL SCIENCES, VIT UNIVERSITY, VELLORE, INDIA
e-mail: ysureshreddy@rediffmail.com , jasmin@vit.ac.in

ABSTRACT

A complete bounding box Gabor filter based minutiae extraction scheme for fingerprint recognition system is presented. The proposed method uses improving alternatives for the image enhancement process, leading consequently to an increase of the reliability in the minutiae extraction task. In the first stages, image normalization, median filtering and orientation field of the fingerprint are calculated. The local orientation of the ridges will serve as parameter for the next processing stages. Details for the morphological filtering used to ridge extraction and back ground noise elimination are described. Conclusions in terms of GAR (Genuine Acceptance ratio), FAR (False acceptance ratio) and FRR (False rejection ratio) of this method are compared with Gabor filter based approach.

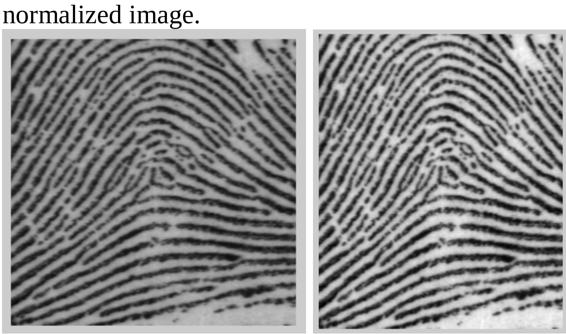
Keywords--Fingerprint, Orientation field, image enhancement, Gabor filter, bounding box Gabor filter minutiae, Verification.

I. INTRODUCTION

Fingerprint Identification is one of the most important biometric technologies which has drawn a substantial amount of attention recently due to its permanence and uniqueness. In security a person could be identified based on the three approaches: something you have, such as Rfid tag: something you know, for example PIN: something you are for example fingerprints. A Rfid tag is easily removed, password is easy to forget and fingerprints, however never lose and never need to remember. A fingerprint is the pattern of ridges and valleys. A total of 150 different local ridge characteristics (Islands, short ridges, enclosure, etc) are present in fingerprint. These local ridge characteristics are not evenly distributed. The two most prominent local ridge characteristics, called minutiae, are ridge ending and ridge bifurcation [2]. A good quality fingerprint typically contains about 40-100 minutiae. The fingerprint enhancement algorithm involves image segmentation also. Segmentation is the process of separating the foreground regions in the image from the background regions. The foreground regions correspond to the clear fingerprint area containing the ridges and valleys, which is the area of interest. The background corresponds to the regions outside the borders of the fingerprint area, which do not contain any valid fingerprint information. When minutiae extraction algorithms are applied to the background regions of an image, it results in the extraction of noisy and false minutiae. Thus, segmentation is employed to discard these background regions, which facilitates the reliable extraction of minutiae. Some conclusions regarding image enhancement, minutiae extraction, GAR, FAR and FRR are also presented [1].

A. NORMALIZATION

Normalization is a pixel wise operation. It doesn't change the clarity of ridges and valleys. The main purpose of normalization is to reduce the variations in Gray-level values along ridges and valleys. Dynamic range of values adjusted such that there is a more balanced distribution between the dark and light pixels. The normalization factor is calculated according to the mean and variance of the image [1].Figure 1 shows original image and corresponding normalized image.

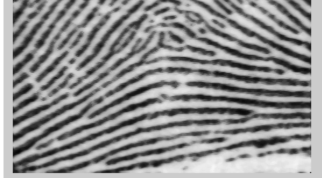


(a) (b)

Figure 1. (a) Original image (b) Normalized image

B. MEDIAN FILTERING

Median filter is one of the denoise processing filter, which is used to remove the salt and pepper noise which is present in the captured fingerprint image. The main advantage of median filter Is that the median value must actually be the value of one of the pixels in the neighborhood, the median filter does not create new unrealistic pixel values when the filter straddles an edge. For this reason the median filter is much better at preserving sharp edges than the mean filter [8]. Figure 2 shows median filtered image.



(a)

Figure 2. (a) Median filtered image.

C. CALCULATION OF ORIENTATION FIELD

The orientation image represents an intrinsic property of the fingerprint images and defines invariant coordinates for ridges and valleys in a local neighbourhood.A number of methods have been proposed to estimate the orientation field of fingerprint images[1],[2],[5],[7]. I used least mean square orientation estimation algorithm.The main steps of the algorithm as follows

(i)Divide an image in to blocks of size W*W(16*16).

(ii)Calculate the gradient values along x-direction (Gx) and y-direction (Gy) for each pixel of the block. Two Sobel filters are used to fulfill the task.The horizontal and vertical sobel operators used to compute are

$$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \qquad \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$$

For each block, use Following formula to get the Least Square approximation of the block Orientation

$$V_x(i,j) = \sum_{u=i-W/2}^{i+W/2} \sum_{v=j-W/2}^{j+W/2} 2G_x(u,v)G_y(u,v) \qquad (1)$$

$$V_y(i,j) = \sum_{u=i-W/2}^{i+W/2} \sum_{v=j-W/2}^{j+W/2} \left(G_x^2(u,v) - G_y^2(u,v) \right) \qquad (2)$$

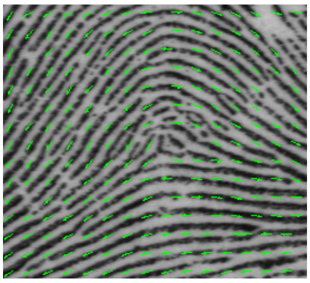
$$V_{xy}(i,j) = \sum_{u=i-W/2}^{i+W/2} \sum_{v=j-W/2}^{j+W/2} \left(G_x^2(u,v) + G_y^2(u,v) \right) \qquad (3)$$

$$\theta(i,j) = (½)\tan^{-1}(V_y(i,j) / V_x(i,j)). \qquad (4)$$

$$\theta(i,j) = \pi/2 + (½)\tan^{-1}(V_y(i,j) / V_x(i,j)). \qquad (5)$$

where Vx(i,j) is a horizontal gradient of each pixel in a block, Vy(i,j) is a vertical gradient of each pixel in a block. θ(i,j) is the Orientation angle of the block.

For orientation plot taking center ,angle of block in to consideration then changing this Cartesian to polar coordinates to x and y .Figure 3 shows Orientation field of the image.



(a)

Figure 3. (a) Orientation field image

D. REGION OF INTEREST

Segmentation is the process of separating the foreground regions in the image from the background regions [1], [4], [5] [7]. The foreground regions correspond to the clear fingerprint area containing the ridges and valleys, which is the area of interest. The background corresponds to the regions outside the borders of the fingerprint area, which do not contain any valid fingerprint information. When minutiae extraction algorithms are applied to the background regions of an image, it results in the extraction of noisy and false minutiae. Thus, segmentation is employed to discard these background regions, which facilitates the reliable extraction of minutiae.

$$E = \{(2 * V_x(i,j) + V_y(i,j)) / (W * W * V_{xy}(i,j))\}. \qquad (6)$$

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

Some morphological operations are performed to expand the images ,to remove the peaks introduced by the background noise and to eleminate small cavities.

E. GABOR FILTER

The image is filtered along the direction of the orientation angle using the value of the frequency obtained for each image. A Gabor filter is used for this process and a suitable value of local variances is taken for carrying out the process of filtering. A Gabor filter takes care of both the frequency components as well as the spatial coordinates [2], [3]. The inputs required to create a Gabor mask are frequency, orientation angle and variances along x and y directions. Filtering is done for each image using the local orientation angle and frequency.

The even-symmetric Gabor filter is the real part of the Gabor function, which is given by a cosine wave modulated by a Gaussian. An even symmetric Gabor filter is defined as

$$G(x,y,\theta,f) = \exp\left(-.5\left((x_\theta^2 / \sigma_x^2) + (y_\theta^2 / \sigma_y^2)\right)\right)\cos(2\pi f x_\theta) \qquad (7)$$

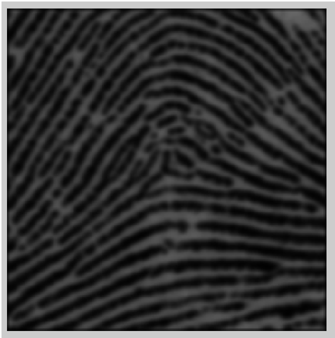
$$x_\theta = x\cos\theta + y\sin\theta$$

$$y_\theta = -x\sin\theta + y\cos\theta$$

Where θ is the orientation of the Gabor filter, f is the frequency of the cosine wave, σ_x and σ_y are the standard deviations of the Gaussian envelope along the x and y axes and x_θ and y_θ define the x and y axes of the filter coordinate frame.

The Gabor filter is applied to the fingerprint image by convolving the image with the filter. It is used at the feature extraction stage of fingerprint, to enhance the ridges and valleys and to extract the features that are present in the fingerprint.The output from Gabor filter is of low contrast image so contrast is adjusted.

Figure 4 shows Gabor filtered image.



(a)

Figure 4. (a) Gabor filtered image

F. BINARISATION

Binarisation is a process of changing the gray scale image in to binay picture. A binary picture has only two different values. The values 0 and 1 are represented by the colors black and white. To perform binarisation on an image, a threshold value in the gray scale image is taking in to account.

Everything darker (lower in value) than this threshold value is converted to black and everything lighter (higher in value) is converted to white. This process is performed to facilitate finding identification marks in the fingerprints such as minutiae.

G. THINNING

Thinning is a morphological operation. It is performed on the binary image, so that the thick ridges in the binary image after several scans become one pixel wide by removing outer bound pixels.

Thinning must be performed with out modifying the original ridge structures of the image [1], [4], [5]. After thinning it is easier to find minutiae and removes a lot of redundant data, which would have resulted in longer process time and sometimes different results.

H. CLEANING

This operation removes isolated pixels i.e. 1's surrounded by zeros. If any one present out of eight zeros this operation not performed. This operation only performed if the center pixel is one and remaining eight pixels should be zeros.

I. MINUTIAE EXTRACTION

Minutiae extraction scheme is performed beyond this morphological operation [1], [4], [5], [6]. If the image is not in quality Minutiae extraction is difficult. Once The minutiae from the cleaned image is obtained then decide whether a pixel belong to a ridge ending or ridge bifurcation, so group of candidate minutiae is obtained. Before extraction of minutiae labeling is given to image to find numbers of connected components .Ridges are black lines and valleys are white lines. A minutia is a combination of ridge endings and ridge bifurcation points.

Ridge ending is a point where ridge ends abruptly. Ridge bifurcation is a point where ridge diverges in to branch ridges. If image pixel equal to 1 then calculating ridge endings and ridge bifurcation points on binary image. For each 3x3 window, if the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending .If the central pixel is 1 and has only exactly 3 one-value neighbors, then the central pixel is a ridge bifurcation. Ridge endings and Ridge bifurcation values are shown in Table I. Figure 5 shows different minutiae present in fingerprint.

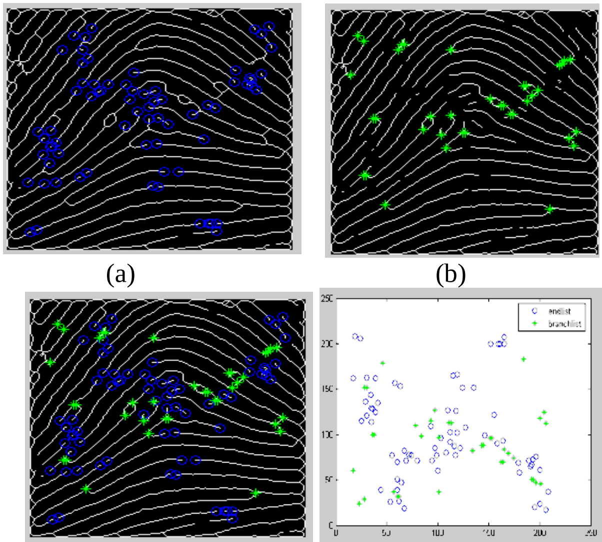
0	0	0
1	1	0
0	0	0

(a)

1	0	0
1	1	0
0	0	1

(b)

TABLE I. (A) RIDGE ENDING TABLE (B) RIDGE BIFURCATION TABLE



(a) (b)

© (d)

Figure 5. (a) Blue color indicates ridge endings of image (b) Green color indicates ridge bifurcations of image.© Both ridge endings and ridge bifurcations (d) Coordinates of both minutiae.

J. MINUTIAE ALIGNMENT

The Extracted minutiae coordinates should store in the database [5]. The Extracted minutiae have two coordinates, one in horizontal wise and one in vertical wise. The Coordinates of ridge endings and coordinates of ridge bifurcations of extracted are then storing in to two separate variables. These two variables are storing in the database not the whole image, so the space that occupies to store these coordinates will be less. This is the main advantage of Minutiae based method.

Ridgeend90= [192		171	52	144
	115	112	113	155
	63	130	61	131
	158	99	100	112
	74	43	45	63

	58	118	53	122
	92	38	24	43
	40	17	101	115
	24	27	193];	
Ridgebifurcation90= [172	193	197	195	
	195	60	71	191
	71	69	207	69
	191	143	143	188
	80	148	85	208
	197	208	197	153];

K. Minutiae matching

A minutia matching is the process of matching the test image minutiae with the database image minutiae [5], [6]. Finding the sizes of ridge endings and ridge bifurcations. Ridge endings of test image coordinates are compared with the ridge endings of database Matched image coordinates. Ridge bifurcations of test image coordinates are compared with the ridge bifurcations of database Matched image coordinates. Finally, Based on the counter operations of Ridge endings and Ridge bifurcations minutiae matching is performed. Identification is a process of matching a coordinates of template image with the coordinates of data base image. Verification is a process of matching other than data base image coordinates with the database image coordinates.

II. BOUNDINGBOXGABOR FILTER

In this method instead of taking whole image, only limited portion of the image is taking for processing. This portion is anywhere in the image but I took center portion of the image because center portion of the image is always enriched with information so minutiae found in this area are taking in to account and leaving all minutiae which are found outside of the bounding box, so missing of any of them are completely avoided. Accessing time is also very less compared to previous method. Figure 6 shows Fingerprint of Bounding box Gabor filter in different stages. Figure 7 shows database of fingerprint image that is stored in different angles.

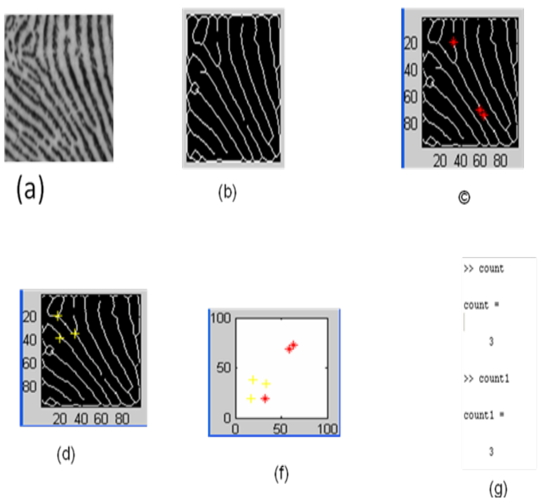


Figure 6. (a) Bounding box image (b) cleaned image (c) Ridge endings of image (RED) (d) Ridge bifurcations of image (YELLOW) (e) Combination of both Minutiae (f) Ridge endings count and Ridge bifurcations count.

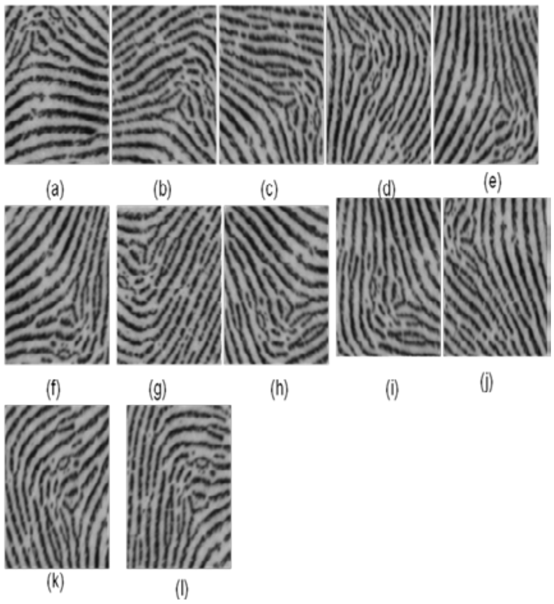


Figure 7. (a) 0 Degree of image (b) 30 Degree of image (c) 60 Degree of image (d) 90 Degree of image (e) 120 Degree of image (f) 150 Degree of image (g) 180 Degree of image (f) 210 Degree of image (i) 240 Degree of image (j) 270 Degree of image (k) 300 Degree of image (l) 330 Degree of image.

III.EXPERIMENTAL RESULTS

The performance of both filters in terms of Genuine acceptance ratio, False acceptance ratio and False rejection ratio of image are calculated and compared are shown in Table II [1].

TYPE OF FILTER	GAR(%)	FRR(%)	FAR(%)
WITH GABOR FILTER	93.75	6.25	1.1
WITH BOUNDING BOX GABOR FILTER	97.05	2.95	0

Table II. GENUINE ACCEPTANCE RATIO, FALSE ACCEPTANCE AND FALSE REJECTION RATES OF TWO FILTERS.

IV.CONCLUSIONS

The reliability of any automatic fingerprint recognition system strongly relies on the precision obtained in the minutiae extraction process. In this paper Minutiae extraction scheme with the Gabor filter enhancement and bounding box Gabor filter enhancement are introduced. The Minutiae extraction coordinates with the Gabor filter enhancement and bounding box Gabor filter enhancement are calculated and compared. Genuine acceptance ratio, False acceptance ratio and False rejection ratio of both the filters are calculated and compared. With the help of Minutiae extraction scheme bounding box Gabor filter enhancement more accurate results are obtained.

V. ACKNOWLEDGMENT

We would like to acknowledge all the people who have assisted us during our work at VIT University.

VI.REFERENCES

[1] Jayadevan R., Jayant V. Kulkarni, Suresh N. Mali, and Hemant K. Abhyankar“A New Ridge Orientation based Method of Computation for Feature Extraction from Fingerprint Images” Transactions on engineering, computing and technology Volume 13 May 2006 ISSN 1305-5313

[2] Lin Hong, Yifei Wan, and Anil Jain, “Fingerprint image enhancement: Algorithm and performance evaluation,” IEEE Trans. on PAMI, vol. 20, pp. 777–789, Aug. 1998.

[3] Shlomo Greenberg, Mayer Aladjem and Daniel Kogan,”Fingerprint Image Enhancement using Filtering Techniques” Real-Time Imaging 8, 227–236 (2002)

[4] S. Cruz-Llanas, J. Gonzalez-Rodriguez, D. Simon-Zorita, and J.Ortega-Garcia, “Minutiae extraction scheme for fingerprint recognition systems,” in Proc. Int. Conf. on Image Processing, ICIP 2001, pp. 254–257.

[5] Ani1 Jain and Lin Hong, “On-Line Fingerprint Verification”, IEEE Proceedings of ICPR ’96, PP.596-600.

[6] F.A. Afsar, M. Arif and M. Hussain, “FingerprintIdentification and Verification System using Minutiae Matching”, National Conference on Emerging Technologies 2004, PP.141-146.

[7] A. K. Jain, L. Hong, S. Pankanti, and R. Bolle, “An identity authentication system using fingerprints,”Proc. IEEE, vol. 85, pp. 1365–1388, Sept. 1997.

[8] L. Yin, R. Yang, M. Gabbouj, Y. Neuvo. “Weighted Median Filters: A Tutorial”, IEEE Trans. on Circuits and Systems, 43(3), pp. 157-192, March 1996.

Suresh reddy .Y.N received his BE degree in Electronics and Communication Engineering from Jayaram College of Engineering and Technology, Trichy, Tamilnadu, India in 2005.He received his ME degree in Communication Engineering from VIT University, Vellore, India in 2007. His areas of interest include Image Processing and Digital Signal Processing.

Jasminfeminapriyadarshini.M received her BE degree in Electronics and Communication Engineering from Thanthai Periyar Govt. Institute of Technology, Vellore, Tamilnadu, India. She received her ME degree in Micro wave and optical Communication from A.C.College of Engineering and Technology, Karaikudi, India. She is currently pursuing her PhD in Optical communication. Her areas of interest include Optical communication, Image Processing and Digital Signal Processing.