International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

A Novel and Efficient Algorithm of Textural Feature Extraction for Fingerprint Identification

S. M. Rajbhoj[1], Dr. P. B. Mane[2]
[1] *Bharati Vidyapeeth Deemed University, Pune, M.S. India*
[2]*Principal, AISSMS IOIT Pune, M. S. India*

Abstract

With the need of automatic personal identification and their extensive use in forensics, fingerprints are receiving a lot of attention. However numerous fingerprint systems currently available still do not meet performance requirement of several civilian applications as they use traditional approach for fingerprint recognition. There is a major disadvantage of traditional approach, as they do not actually utilize the rich discriminatory information contained in fingerprint. Thus trying to eliminate this shortcoming we present an improved & efficient approach for fingerprint recognition providing accurate automatic personal identification. Here we extract the local ridge features of fingerprint image by a bank of 16 Gabor filters divided in squared blocks. The matching is based on Euclidian distance between Finger codes. Hence this approach make use of orientation and frequency of local ridge structure which is the rich discriminatory information in fingerprint, secondly square tessellation covers the entire image and Euclidian distance based matching of finger codes increases the speed of matching process.

1. Introduction

Biometric recognition, or simply biometrics, refers to the automatic recognition of individuals based on their physiological and/or behavioural characteristics. Some of the physiological and/or behavioural 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] [3]. The minutiae based approach [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 features may not be very discriminative in case of solid state sensors which usually capture only a small area of fingertip. Also in case of poor quality images it is difficult to accurately locate minutiae points. 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.

The other approach which use global information is non minutiae feature based approach. This uses local and global textural information as an alternative to minutiae. The most popular technique to match fingerprint using textural information is Finger code approach by Jain et al. [5], here fingerprint area of interest was tessellated with respect to the core point and feature vector was composed of features extracted from local information of each sector. Gabor filterbank technique [6] was used to capture textural information. The alignment of grid defining the tessellation with respect to core point was one critical point in this approach. When the core point was not detected reliably or when it was close to the border of fingerprint area, the finger code was incompatible with the template. Ross and Prabhakar [7] and Ross, Jain and Reisman [8] also proposed variant to this methods.

2. Fingerprint as an oriented texture

The pattern of ridges and furrows on the surface of a fingertip can be viewed as oriented texture field. The uniqueness of a fingerprint is determined by the ridge characteristics and their relationships. These ridge characteristics are not evenly distributed. Hence fingerprint can be represented by using measures associated with flow or texture pattern as features. An effective strategy to improve the robustness is to exploit a global model of orientation image which makes use of the texture features available on fingerprint. A global representation of texture by decomposing the image into different frequency and orientation component using Gabor filter was used by Daugman to extract textural features of iris [9].

Here we present novel texture based approach for fingerprint recognition. In this approach we extract the oriented texture pattern which observed at various resolutions and orientations, provide discriminatory information. Further, it is easier to detect ridge feature in poor quality images. The local ridge characteristics is extracted via a set of 16 Multi-resolution filters that are pre-tuned to a specific frequency corresponding to the average inter-ridge spacing in a fingerprint image. An input enhanced fingerprint image is filtered using this set of Multi-resolution filters. A square tessellation is then applied to each filtered image to examine the local response to the filters; feature vector which measures the energy in the filtered images for each of the tessellated cells is obtained. A collection of these feature vectors (over the tessellation) constitutes the ridge feature map. This ridge feature map represents a fingerprint as an oriented texture pattern. The query feature map and the template feature map are matched. This matching will generate a score which is passed to decision module.

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 concludes the paper.

3. The Proposed fingerprint System

The block diagram of proposed fingerprint system is as shown in figure 1.

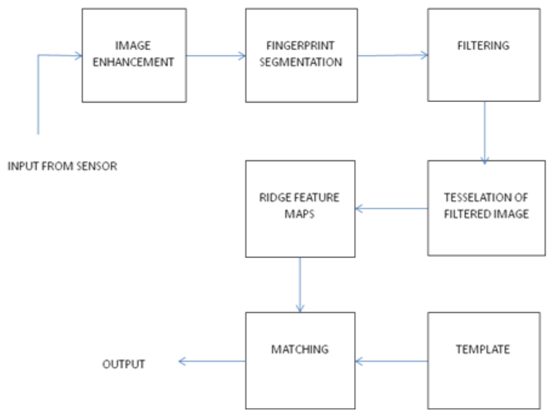

Figure 1: Block Diagram of Proposed system

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 the features are extracted. The third stage is a matching algorithm that gives 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.

3.1. Fingerprint Sensor

We have used U.are.U 4500 Fingerprint Reader [10] as a fingerprint sensor. The U.are.U 4500 Reader is a USB fingerprint reader 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. Digital Persona readers utilize optical fingerprint scanning technology to achieve an excellent image quality [512 DPI], a large capture area [14.6 x 18.1] and superior reliability. Optical sensor is 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.

3.2. 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 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 neighbourhood where no minutiae points appear, the grey levels along ridges and furrows can be modelled 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. After filtering we get the enhanced image [11]. 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 and are not used.

Figure 2 shows various outputs of the pre-processing steps of fingerprint images.

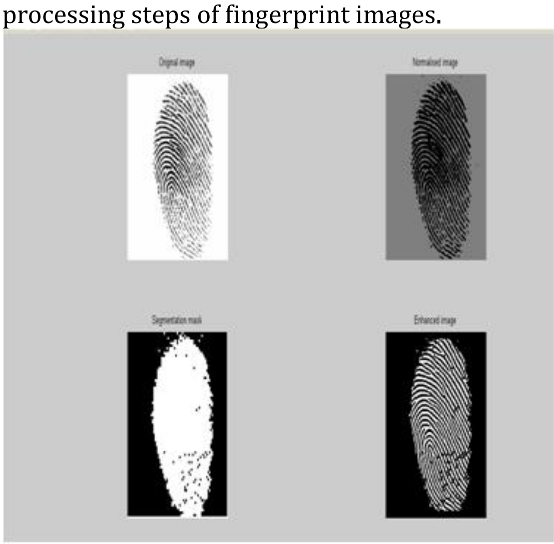

Figure 2: Fingerprint Pre-processing.

3.3. Filtering

Filtering is performed on the segmented enhanced image. The filtering is performed in frequency domain as filtering in frequency domain speed the filtering operation. It consists of convolution of the enhanced image with Gabor filter. A 2D Gabor filter can be viewed as a complex plane wave modulated by a 2D Gaussian envelope. These filters capture both local orientation and frequency information, which can be obtained by tuning a Gabor filter to a specific frequency and direction. Thus, it is useful for extracting texture information from images.

An even symmetric Gabor filter has the following general form in the spatial domain:

$$G_{\theta,f(x,y)} = \exp\left\{\frac{-1}{2}\left[\frac{x'^2}{\delta_x^2}+\frac{y'^2}{\delta_y^2}\right]\right\}\cos(2\pi f x')$$

$$x' = x\sin\theta + y\cos\theta,$$

$$y' = x\cos\theta - y\sin\theta\,,$$

Where, f = frequency of sinusoidal plane wave at an angle ɵ with the x axis. δx and δy = standard deviations of Gaussian envelope along the x and y axes respectively.

We have set frequency as 0.125, as average inter-ridge spacing is about 8 pixels in case of (500 dpi image). f=1/8=0.125. The values of standard deviation δx and δy are set to 4 as an trade-off because large values do not capture ridge information at fine level and small values are less robust to noise. We have examined sixteen different orientations. These corresponds to Θ values of 0°,11.25°,33.75°,45°,56.25°,67.5°,78.75°,90°,101.25°,112.5°,123.75°,135°,146.25°,157.5°,168.75°.

Thus Gabor filtered image Vɵ may be obtained as,

Vθ = F-1[F(H) *F (Gɵ)]

Where F-1 is inverse fourier transform.

F (H) denote the Discrete Fourier Transform of enhanced image H

F (Gɵ) denotes the Discrete Fourier transform of Gabor Filter having spatial orientation ɵ.

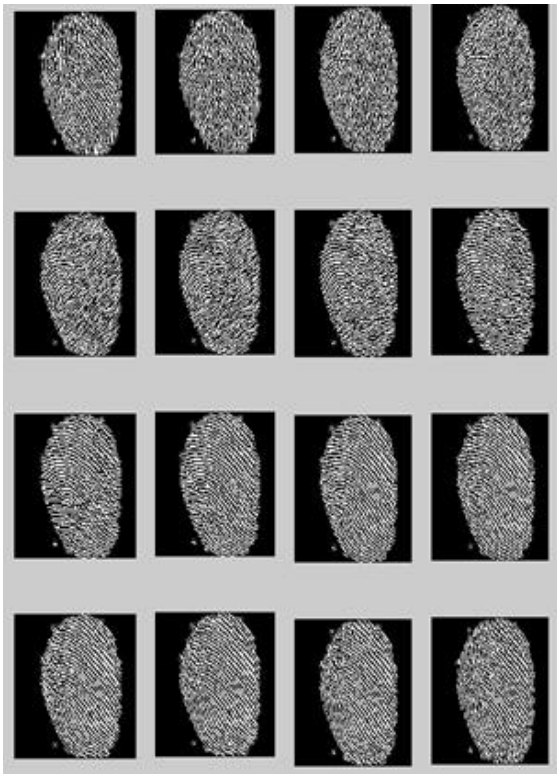

Figure 3: Gabor filtered Images

A set of 16 Gabor filters, is used to capture the ridge strength at equally spaced orientations and frequency information. The output of these filter are shown in Figure 3.

3.4. Square tessellation of filtered images

To examine local variation that provide a better representation of the fingerprint, the image is tessellated into square cells instead of circular, which makes the process independent of core point, then features from each of the cells are computed. The size of a cell is chosen to correspond to approximately the width of two ridges (16 × 16). An 8 pixel wide border of the image is not included in the tessellation. This results in n=15 cells in each row and column of the square grid. The total number of tessellated cells over the image is, therefore, N = 225.

3.5. Ridge feature Map

The variance of the pixel intensities in each cell across all filtered images is used as a feature vector or code. This variance corresponds to the energy of the filter response, and is, therefore, a useful measure of ridge orientation in a local neighbourhood. The feature map is obtained by combining all the finger codes to construct a 16-dimensional feature map, called the ridge feature map. Those tessellated cells that contain a certain proportion of background pixels are labelled as background cells and the corresponding feature value is set to 0 and not used. This ridge feature map is then stored as a template for matching.

3.6. 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. Here, the matching is based on Euclidean distance between the two corresponding finger codes. The ridge feature maps of the query & template images are compared by computing the sum of the Euclidean distances of the sixteen-dimensional feature vectors in the corresponding tessellated cells and the minimum Euclidean distance indicates positive match.

4. 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 (300 x 300 image 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) images was collected in this way. The second database used was the standard FVC2004 database [12]. These databases consist of four databases with two sets of evaluation and training. Evaluation set is (100x8) images and training set is (10x8) images. 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 performance of this system is 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. 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 scores are obtained, when feature vectors from same individuals are compared. The ROC curves showing the performance of the system for our database and FVC2004 is shown in the Figure 4 and Figure 5.

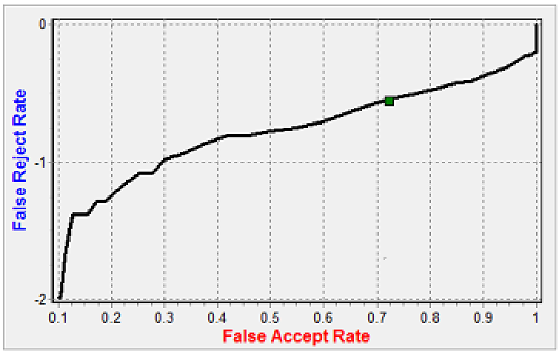

Figure 4: ROC Curve of system for our database

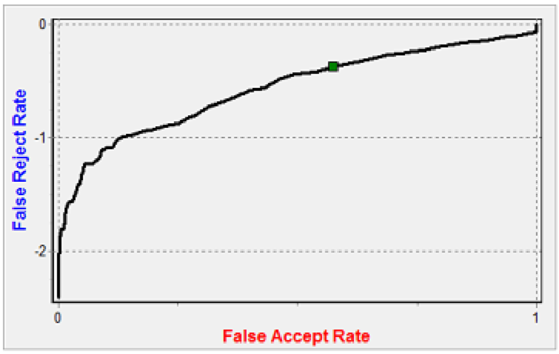

Figure 5: ROC Curve of the system for FVC2004 database.

Experiments were carried out by changing the block size of tessellations and by using Gabor filter with 8 and 16 orientations. It was found that smaller block size of tessellations does not have significant difference in performance accuracy. When the enhanced image is subjected to Gabor filters with 8 orientations, the genuine and imposter curves in the histogram were overlapping. After taking the 16 orientations, this overlapping was reduced which increased the accuracy of the program. We have got an EER of 0.7242 and 0.5752 for our database and FVC database. On an average program takes 14 to 15 seconds to show outputs. For storing a single fingerprint image we require 142KB memory, whereas after processing the image, the image template requires only 42KB memory. Thus, the size of memory required for storing the template is greatly reduced.

5. Conclusion

This paper presents an improved & efficient textural based approach for fingerprint recognition providing accurate automatic personal identification. This approach uses rich global discriminatory texture information contained in the fingerprint image unlike minutiae based approach which uses only local information (minutiae points). In some image where it is difficult to locate minutiae points this technique can be advantageous. The performance and accuracy of the code is better as compared to minutiae based approach. The proposed technique has the following features The square tessellation of the filtered image covers the entire image so image data is not lost as in case of circular tessellation. Filtering and ridge feature map extraction are implemented in the frequency domain thereby speeding up the matching process. It was found that smaller block size of tessellations does not have significant difference in performance accuracy. Using Gabor filter with 16 orientations, the overlapping the genuine and imposter curves was reduced which increased the accuracy of the program. It takes 14 to 15 seconds to show outputs and memory required to store template is only 42KB memory. Thus, the time required for matching is reduced.

10. 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] A. K. Jain, L. Hong, and R. Bolle. "On-line fingerprint verification," IEEE Transactions on PAMI, 19(4):302–314, April 1997
[5] Jain A.K., Prabhakar S., Hong L. and Pankanti S. "FingerCode: A Filterbank for Fingerprint Representation and Matching," in Proc. Conf. Computer Vision and Pattern Recognition, vol. 2, pp. 187–193, 1999.
[6] Anil K. Jain, Salil Prabhakar, Lin Hong, and Sharat Pankanti, "Filterbank-based fingerprint matching" IEEE Transactions on Image Processing, vol. 9, no. 5,pp. 846–859, May 2000.
[7] Prabhakar, S. and Jain, A. K. "Fingerprint Matching Using Minutiae and Texture Features." in Proc. Int. Conf. In Image Processing, pp282-285,2001.
[8] A. Ross, A. K. Jain, and J. Reisman, "A hybrid fingerprint matcher," Pattern Recognition, vol. 36, pp. 1661–1673, Jul 2003
[9] J. Daugman, "Recognizing person by their iris pattern," in A. K. Jain, R. Bolle, and S. Pankanti, editors, Biometrics: Personal Identification in a Networked

Society, pages 103-121 Kluwer Academic Publishers, 1999.
[10]http://www.digitalpersona.com/Biometrics/Hardware-Products/U-are-U-4500-Reader/4500-Reader/
[11] 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
[12] http://biometrics.cse.msu.edu/fvc04db/index.html.