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A Gabor filter approach of Fingerprint Recognition with Multiple Orientations

D.N.V.Ashok
Department of ECE
Vignan's Institute of Information Technology
Visakhapatnam, India
E-mail: ashokdnv@gmail.com

Mrs.Y.Sukanya
Department of ECE
Vignan's Institute of Information Technology
Visakhapatnam, India
E-mail: sukanya_ece@rediffmail.com

Abstract: Fingerprint recognition has been one of the finest strategies for the bio metric identification, because of its high degree of exactness. Also getting a decent finger impression is a tedious job. Consequently a finger print image must experience a portion of improvement methods. The principle target of this work is to enhance the finger print image by utilizing FFT and Gabor filter. In frequency domain filtering, the finger print image is divided into 16*16 small frames and the Gabor filter with 16 different orientations were considered and outputs from these two channels are combined to form a final enhanced image. The enhanced image finally obtained is subjected to binarization and thinning techniques, here it converts the entire image into white (1's) and dark (0's) pixels and the ridges are minimized to pixel width of unity. The minutiae parts which were acquired by this procedure are compared with different images in the database and the matching process takes place. The proposed method has more than 96% of the recognition rate which is better than histogram method. Matlab is the major tool for the implementation of the project.

Keywords: Gabor filter, Biometrics, Binarization, Thinning, Minutiae, Frequency Domain Filtering.

I. INTRODUCTION

Sophisticated systems have became daily necessary commodity in today's world, hence it obvious requirement of reliability of the system. User identification scheme with their own characteristics provide the utmost response. Hence the most prominent way of identification and recognition is – Biometrics.

Why biometrics?

- Biometric differs from individual to individual.
- Unlike password, pin word there is no chance for forgotten, misplaced, lost (or) stolen.
- User unique biometric signature is used as an identification tool.

Why fingerprint as biometric?

- The accuracy rate using a fingerprint as biometric is higher when a system is known for its user friendliness.
- Because of the compact size of fingerprint scanners they can be easily integrated on to electronic gadgets.
- It has been chosen as the choice for workplace access security because of its low cost.

When compared all biometric techniques fingerprint based identification method is the oldest one and has been successfully deployed in number of applications because of the fact that every user is provided with a unique fingerprint characteristics.

The following are the stages included in the fingerprint recognition:

1. Scanning (capture & acquisition).
2. Extraction.
3. Comparison
4. Final matching / Non-Matching.

A fingerprint consists of a series of ridges on the surface of the finger. The determination of the uniqueness of a fingerprint is solely based on the pattern of the ridges and the minutiae points [1].

The reliable extraction of minutiae points from the input fingerprint images is the major step in the fingerprint matching process. Many algorithms have been developed in order to recognize the certain patterns but the performance of particular algorithm is highly dependent on the quality of the fingerprint image which has been considered as an input.

In the minutiae extraction module the fingerprint enhancement algorithm occupies the major role because of the fact that the performance of any user identification system is dependent on the quality of input image.

Figure1.Fingerprint Description

II. FFT AND GABOR FILTER

The representation of an image into its real and imaginary components will be accomplished using Fourier transform. Whenever the input signal is an image then the number of frequencies in the frequency domain and number of pixels in the spatial domain are one and the same. The transformation of N points can be rewritten as the sum of two N/2 transforms. Since the FFT is a divide and conquer algorithm, hence it involves multiple passes in its implementation. These passes are called butterflies. If the height and the width of the image are required then only one texture can be useful for the butterfly values for both the horizontal and vertical passes. The steps in implementing FFT algorithm are:

- Compute Indices and weights.
- Compute horizontal butterflies $\log_2$ (width).
- Compute vertical butterflies $\log_2$ (height)

The filter which obeys the linearity property is known as linear filter. Gabor filter comes under the category of linear filter whose impulse response can be derived by multiplying the Harmonic function with Gaussian function. By applying the Convolution theorem, the impulse response of Gabor filter is same as the Fourier transform of both Harmonic function and Gaussian function. Gabor filter which is named after Dennis Gabor has found its immense application in the field of image processing for Edge detection. The operating frequency of Gabor filter and its orientation were quite similar to that of human visual cortex and it is highly appropriate for the representation and discrimination of texture [2]. Gabor filters are mainly used for texture segmentation because of their good spatial and spatial frequency localization. For modulated a 2-D linear Gabor filter a sinusoidal plane wave has been used, which is considered as the Gaussian kernel function in spatial domain.

$$G_i(x,y) = \frac{1}{2*pi*sx*sy} * \exp([-\frac{1}{2}\{(\frac{x^2}{sx^2}) + (\frac{y^2}{sy^2})\}]) * M_i(x,y,f)$$

$$i = 1,2;$$

$$M_1(x,y,f) = \cos(2*pi*f*sqrt(x^2+y^2))$$

$$M_2(x,y,f) = \cos(2*pi*f*(x*\cos\theta + y*\sin\theta))$$

Apart from edge detection the Gabor filter can also be used for Fingerprint, iris, and Face Recognition.

III. PROPOSED ENHANCEMENT

In order to improve the interpretability (or) perception of image information for human viewers is the main reason behind the Image Enhancement. Image Enhancement technique is broadly classified into two categories:

- Frequency Domain Methods, which operates on the Fourier Transform of an image.
- Spatial Domain Methods, which operates directly on the pixels.

The above mentioned Image enhancement techniques were considered as the preprocessing tools for several other Image processing techniques. The improvised clarity of ridge structures in the recoverable region is the main aim of fingerprint enhancement [3].

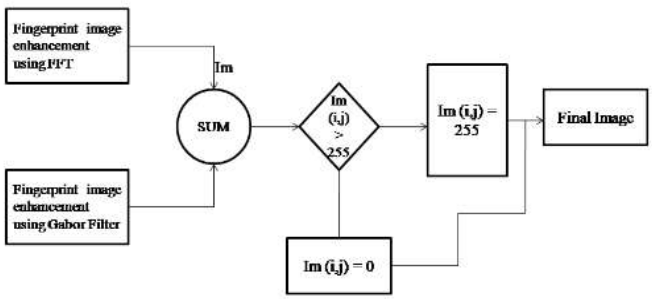


Figure2. Block Diagram of Enhancement Technique

The input fingerprint image is subdivided to 16*16 small block of frames and this subdivided image undergoes Fourier Transformation which has been represented by the following mathematical model:

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) * \exp\{-j2\Pi * (\frac{ux}{M} + \frac{vy}{N})\}$$

For u = 0, 1, 2 …… 15 and v = 0, 1, 2 …… 15.

After applying the FFT each block magnitude raises multiple times to enhance a particular block by its dominant frequencies.

The two important properties of Gabor filter are:

- Orientation Estimation.
- Ridge Frequency Estimation.

The least mean square estimation is employed for the computation of orientation image. Here in this method the pixel wise estimation is preferred over block wise estimation as the main idea is getting a finer and more accurate orientation field.

The Ridge frequency estimation is used to determine the local frequency of ridges in the fingerprint. The image is subdivided into (M*M) number of blocks and it is followed by projection of gray level values of every pixel located in the block along the orthogonal direction to the ridges in the fingerprint. A sinusoidal shape wave with local minimum points will be developed due to this projection. The smoothening of this waveform will be done by using Gaussian low pass filter in order to reduce the noise in the image. The ridge spacing is computed by counting the average number of pixels, and then the fingerprint is finally scanned at a fixed resolution. Moreover, there are some cases where a valid value of frequency cannot be obtained from the projection and also due to the presence of minutiae points in the block which can lead to the improper sinusoidal shape wave which in turn causes the inaccurate ridge frequency estimation [4].

The output image thus obtained by combining the FFT and Gabor filter which are operating in frequency and spatial domain has improved image enhancement characteristics. From these final image minutiae features were observed.

IV. BINARIZATION AND THINNING

The process of converting the 256-levelled images into a 2-level image without any degradation in the image information is known as Binarization. The binarization plays a major role in ridge extraction. The Binarized image purely consists of zeros and ones. In a binary image the background pixel is always assigned with a value of 0 and where as the object pixel is assigned with a value of 1(white as 1 & black as 0). Due to the fact that the fingerprint image will not have similar contrast characteristics such that different global thresholding can't be chosen. In order to binarize a fingerprint a locally adaptive method is deployed in which the images are divided into small blocks and the mean intensity values are calculated for each block [5]. Consequently, if the value of the pixel intensity is greater than mean intensity value then the value of the pixel is one.

A morphological operation i.e., used to nullify the redundant pixels of a binary image. Among the various morphological operations, thinning algorithm has its own importance because it preserves the extent connectivity of original image while leaving away all the foreground pixels [6]. Thinning technique has several applications but it is practically useful in skeletonization of binary image to tidy up the outcome of edge detectors by reducing all lines to the single pixel thickness. Thinning operator considers two sets of data one being the input fingerprint image which gives the prominent details of image. Thinning can be achieved by implementing two methodologies namely iterative and non-iterative. An iterative algorithm includes multiple scans in order to achieve the skeletonized ridge structured binary image.

V. MINUTIAE EXTRACTION

The minutiae point extraction involves estimation of ridge endings and ridge bifurcations. If the neighbor pixel value of a ridge is one then it is a ridge ending. If it is two or more then it is ridge bifurcation. Even after enhancement of the fingerprint image some false minutiae points will appear because of presence of ridge breaks [7]. These pseudo minutiae points can be removed during the post processing stage.

These false minutiae points can be eliminated by using a (5*5) window mask. To verify the validation of minutiae point a (5*5) mask is taken into consideration where the ones and zeros are placed in accordance to the threshold limit. A (N*N) window is considered at the exact location of the minutiae point and square of the mask size is computed which rises two cases, when the sum is small when compared to N^2 then the particular minutiae point is invalid. On the other hand if the sum is as same as N^2 it states that the minutiae point is not on the border. From this we can know that this point can be preserved by eliminating those points which are existing at the border [8].

The minutiae points which are present at the border must be removed, to accomplish that a window of (N*N) size is placed at each minutiae point as its centre and it checks whether any external minutiae points are included in that block and they will be eliminated. Thus minutiae points due to ridge breakings are eliminated.

VI. IMPLEMENTATION OF BLOCK DIAGRAM

The emphasis in this essence is to perform matching process between the images in the database and the user's input fingerprint. The database comprises of fingerprint images of multiple persons with variety of orientations. The testing process is performed between the input image and the images from the database. Both the input image and the database images consist of their own templates. Angle of orientations, Ridge bifurcations and Ridge endings together form a test template. The test template of both the input fingerprint image and the database images will be compared with each other and

based on the threshold level the comparison rate can be explicitly determined.

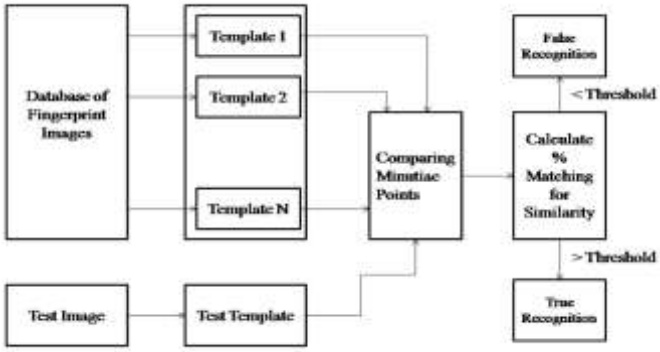


Figure3.Block diagram of Fingerprint Matching

The entire procedure involved in the Gabor filter approach of fingerprint recognition with multiple orientations has stated as follows: Database collection, enhancement using FFT and Gabor filter to the input image, proposed enhancement, binarization, thinning, minutiae extraction, and finally calculation of Euclidean distance [9].

The database consists of 72 images which were formed by collecting 8 different finger prints of 9 different persons. The input image is taken from a particular user and it applied to frequency domain filter in which the image is sub-divided into 16*16 small frames, the features of an image can be extracted and combined with the output of a 16 oriented gabor filter. The resultant output combined image will undergo binarization technique in which the dark pixels values are assigned to binary 0 and the bright pixel values are assigned to binary 1. The outcome of the binarization technique is a binary image and it is further subjected to thinning. The outcome from this thinning technique will gives rise to a skeleton structure of binary image. Minutiae of the skeleton structure were marked as the receipt of recognition and the Euclidean distance between the minutiae points is calculated and based upon this value the similarity rate will be determined [10].

In the proposed method, while matching the finger print with the database there is a false recognition because of different alignments of the finger prints in the database. Due to this the matching process is not accurately determined. In order to overcome this problem the database can be aligned in a certain manner that the core of the finger print comes in the center and is oriented in a particular direction. In this manner the database is recreated. Through this phenomenon the false recognition rate comes down while the accuracy rate increases.

VII. RESULTS AND DISCUSSIONS

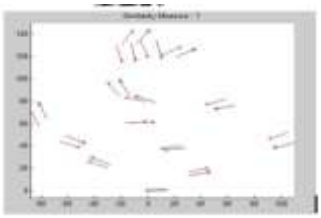
The recognition rate of the finger print images in the proposed method has been increased more than 96%, which is more when compared to the recognition rate of the histogram process which is only having a recognition rate of 64%.

Figure4. Input Image

Figure5. Enhanced Image

Figure6. Binary Image

Figure7. Minutiae on Thinned Image



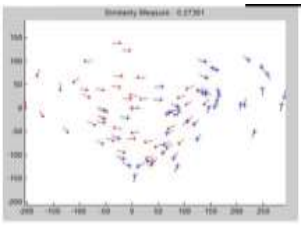


Figure8. Similarity of Same fingerprint. **Figure9.**Similarity of different images

VIII. CONCLUSION AND FUTURE SCOPE

From the simulated results it is concluded that, the matching efficiency will be increased when compared to the histogram technique and previously proposed method (with 32*32frame FFT and 8 orientation Gabor filter). The false recognition rate can also be minimized by altering the database finger print images to a particular basic alignment. Along with the Euclidean distance between the minutiae points, the corresponding neighborhood pixel values and co variance values can be estimated for the matching process. This is the proposed future work to this paper.

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AUTHOR'S BIOGRAPHIES

Mr. D. N. V. Ashok was born in 1992 at Karamchedu. He received his B.Tech in Electronics and Communication Engineering from S.R.K.I.T in 2014 and his M.tech in Digital Electronics and Communication System from Vignan's Institute of Information Technology in 2016. His area of interest is Image Processing.

Mrs.Y.Sukanya was born in 1978. She received her BE degree in ECE department from S.R.K.R Engineering collage, Affiliated to AU, Bheemavaram, and obtained her M.tech degree in Digital Electronics and communication Systems from Gudlavalleru Engineering Collage. She has 13 years of teaching experience, currently working at Vignan's Institute of Information Technology, Visakhapatnam as Associate Professor in department of ECE. Her areas of interest are Communication Systems, Image Processing and Signal Processing.