Finger Print Identification Using DWT by Real Minutiae Extraction

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Abstract— **Fingerprint is a biometric that provides secure process to authenticate a person due to its permanent feature and uniqueness that stay behind throughout human life. It has been in used for more than 100 years as a result of its achievability, reliability, accuracy, and acceptability. Although there exist many algorithms for fingerprint authentication, there is still a need to close the gap of accurateness. Among the algorithm of fingerprint methods are minutiae matching and pattern matching method. A minutiae matching is widely used for fingerprint recognition and can be classified as ridge ending and ridge bifurcation. In this paper the minutiae extraction method was improved by combining it with image enhancement that includes noise reduction, smoothing, contrast stretching, histogram equalization, wavelet transform and edge enhancement. For the image preprocessing steps, we have used histogram equalization followed by wavelet Transform to do the image enhancement and then image binerization is done by locally adaptive threshold method. This method presented a satisfactorily performance.**

Keywords— **Minutiae extraction, minutiae matching, fingerprint, biometrics, fingerprint enhancement.**

1. INTRODUCTION

Fingerprint recognition or fingerprint authentication refers to the automated method of verifying a match between two human fingerprints. Fingerprints are one of many forms of biometrics used to identify an individual and verify their identity. Because of their uniqueness and consistency over time, fingerprints have been used for over a century, more recently becoming automated (i.e. a biometric) due to advancement in computing capabilities. Fingerprint identification is popular because of the inherent ease in acquisition. For a long time, researchers had come up with many approached identify and verify a fingerprint. Although the position, type of minutiae, ridges and many other parameters are used, the results are still not satisfied in recognizing fingerprint. However, all fingerprint recognition verification or identification, are eventually based on a well-defined representation of a fingerprint. The underlying principle of well-defined representation of a fingerprint and matching remains the same. The verification would be straightforward if the representation of fingerprints remains the uniqueness and kept simple.

2. FINGER IDENTIFICATION SYSTEM

An identification system can be defined as the one which helps in identifying the individual from many people available. It generally involves matching available biometrics feature like fingerprint with the fingerprints which are already enrolled in the database.

A fingerprint identification system constitutes of fingerprint acquiring device, image preprocesses and minutia extractor and minutia matcher.

During the fingerprint image preprocessing stage, Histogram Equalization and Fourier Transform were deployed to perform image enhancement. And then the fingerprint image is binarized using the locally adaptive threshold method. The image segmentation task is fulfilled by a three-step approach: block direction estimation, segmentation by direction intensity and Region of Interest extraction by Morphological operations. Most techniques used in the preprocessing stage are developed by other researchers but they were structured as a new combination in this work through various tests.

The minutia matcher chooses any two minutiae as a reference minutia pair and then matches their associated ridges first. If the ridges match well, two fingerprint images are aligned and matching is conducted for all remaining minutiae.

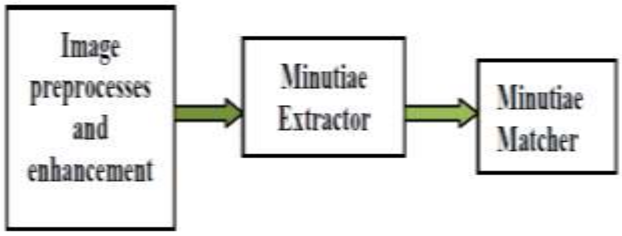

Figure 1: Basic Fingerprint Identification System

3. PROPOSED METHODOLOGY

3.1 FINGERPRINT IMAGE ENHANCEMENT

Fingerprint image enhancement is to prepare the image to be better to ease further operations. Since the fingerprint images acquired from camera or other sensors are not guaranteed with great quality, thus image enhancement need to be carried out.

3.1.1 ENHANCED BY USING HISTOGRAM EQUALIZATION

The fingerprint images were first enhanced by using Histogram Equalization. Histogram is a process that attempts to spread out the gray levels in an image so that they are evenly distributed across their range. It basically reassigns the brightness value of each pixel based on the image histogram. Histogram is a technique to produce more visually pleasing result across a wider range of images to produce as flat as possible histogram of the image.

Figure 2: Histogram Enhancement (left: original image, right: enhanced image)

3.1.2 ENHANCEMENT THROUGH WAVELET TRANSFORM

A signal is passed through number of filters for decomposition. First it is passed through low pass filter to give approximation coefficients and this signal is also decomposed by high pass filter that gives detail coefficients. After that 2nd down sampling is performed on the filters outputs.

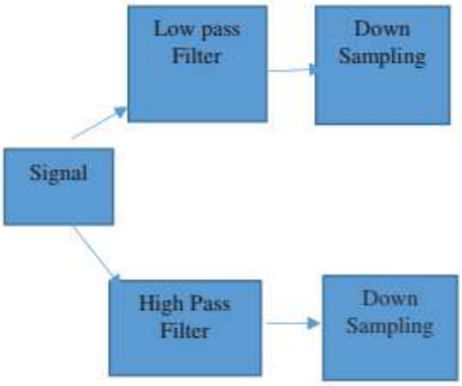

Figure 3: Wavelet Decomposition

Wavelet transforms are multi-resolution image decomposition tool that offer a diversity of channels expressive the image feature by dissimilar frequency sub bands at multi-scale. It is a well-known technique in analysing signals. When putrefaction is executed, the approximation and detail component can be separated 2-D Discrete Wavelet Transformation (DWT) translates the image from the spatial domain to frequency domain. The image is divided by vertical and horizontal lines and represents the first-order of DWT, and the image can be separated with four parts those are LL1, LH1, HL1 and HH1.

To apply wavelet transform in images, the extension to 2D has to be made. For 2D data, the transform can be categorized into separable and non-separable transform. Most discrete wavelet transform in 2D data is performed using the separable wavelet transform. For the separable transform, the two dimensional wavelets are defined as tensor products of 1D wavelets. This results in one scaling function and three different mother wavelets:

$$\phi[i,j] = \phi[i]\phi[j]$$
$$\Psi_1[i,j] = \phi[i]\Psi[j]$$
$$\Psi_2[i,j] = \Psi[i]\phi[j]$$
$$\Psi_3[i,j] = \Psi[i]\Psi[j]$$

This type of product allows one dimensional filtering of rows, followed by one dimensional filtering of columns, instead of two dimensional filtering. This results in four different filtered images (Figure 4.5); one of which represent the approximation, namely the low-low (LL) channel, while the other three represent the details, namely the low-high (LH) channel, high-low (HL) channel and high-high (HH) channel. LL is a smoothed version of the original image, while the detail images LH, HL and HH contain respectively the details of the vertical, horizontal and diagonal directions, thus retaining specific orientation information. After this, a sub sampling in both directions can be performed. As in the one dimensional case, by iterating the procedure on successive low pass images LL, sub images LL on different levels are generated. This results in a pyramid with detail images for different scales and orientations, and is called two dimensional standard or pyramidal wavelet decomposition.

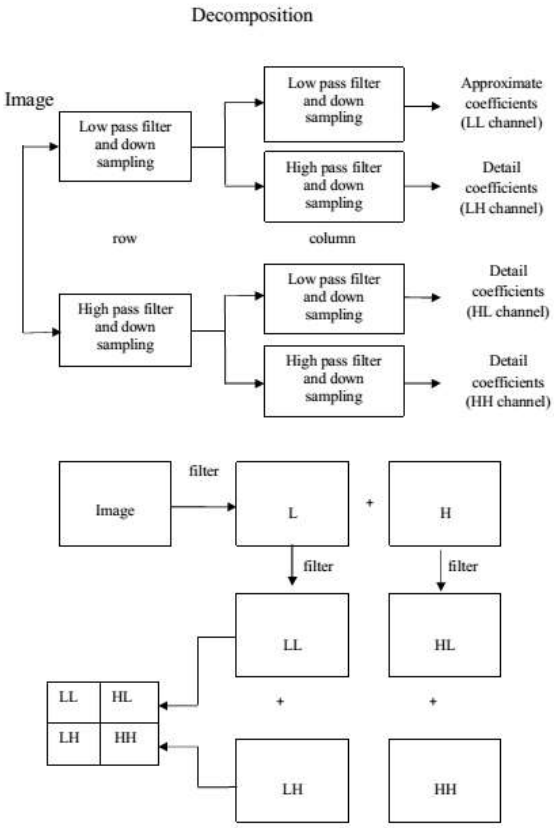

Figure 4: One level wavelet decomposition of two dimensional data

In this enhancement, the image is divided into small processing blocks of 32by 32 pixels and then we perform the Wavelet Transform on each block according older concept of FFT as:

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

$for\ u = 0,1,2, \ldots .,31$, and

$for\ v = 0,1,2, \ldots .,31$.

In order to enhance each block by its dominant frequencies, each block after DWT will be multiplied with its magnitude a set of times. Where magnitude can be given as:

$abs\big(F(u,v)\big) = |F(u,v)|$

and the enhanced block will be based on:

$$g(x,y) = F^{-1}\{F(u,v) \times |F(u,v)|^k\}$$

$where\ F^{-1}\{F(u,v)\}\ is\ given\ by$

$$F(x,y) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} F(u,v) \times exp\left\{j2\pi \times \left(\frac{ux}{M} + \frac{vy}{N}\right)\right\}$$

$for\ x = 0,1,2, \ldots, 31$, and
$for\ y = 0,1,2, \ldots, 31$.

The k in the formulae is a constant which is determined experimentally, here we will choose the k value = 0.45 by some experiments over fingerprints. Suppose, if we have a higher 'k' then the appearance of the ridges will be improved and it will fill up the small holes in ridges but, if have a very higher 'k', then it can result into false joining of ridges. Hence, termination minutiae might become bifurcation minutiae.

Figure 5 represents the image after DWT enhancement where figure 6 is the image after histogram equalization

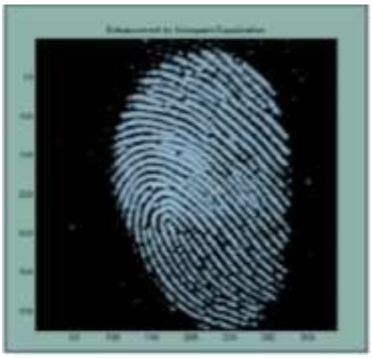

Figure 5: Histogram equalized image

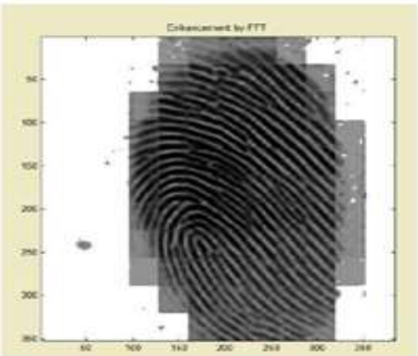

Figure 6: Image after DWT operation

3.2 FINGERPRINT IMAGE BINARIZATION

Fingerprint image binarizationis done to transform a 8-bit gray image to a 1-bit binarized image where 0-value holds for ridges and 1-value for furrows. And after the binerization operation ridges are highlighted with black color and furrows are highlighted with white color.

Here, we will use a locally adaptive binerization method called as 'adaptive thresholding' to binarize the fingerprint image. In this method we transform the gray level to 0 if it is below threshold value and to 1 if it is above threshold value. The threshold value is the mean taken from the gray level of the current block (16*16) to which the pixel belongs [Figure 7].

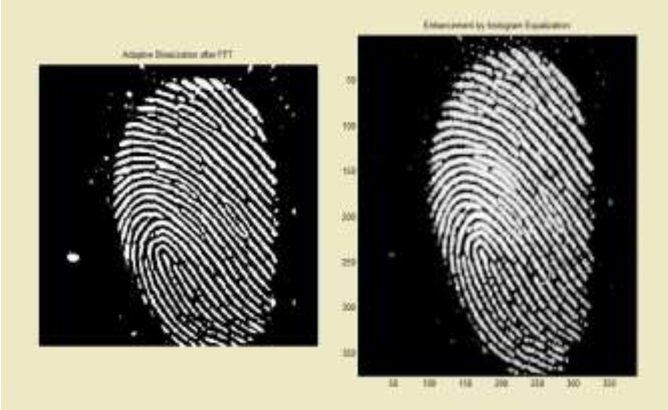

Figure 7: Binarized image (left), histogram equalized image (right)

3.3 FINGERPRINT IMAGE SEGMENTATION

As for our aim only region of interest is the useful part which needs to be recognized for each and every fingerprint image. Here, the image area without effective furrows and ridges will be first discarded from the image since it has only background information. Then we will sketch out the bound of the remaining effective area since bound region minutiae produces confusion with the spurious minutiae that are generated out of the sensor.

To get the ROI we use a two-step method. The first step constitutes 'block direction estimation' and 'direction variety check', whereas the second step is done using some morphological operations.

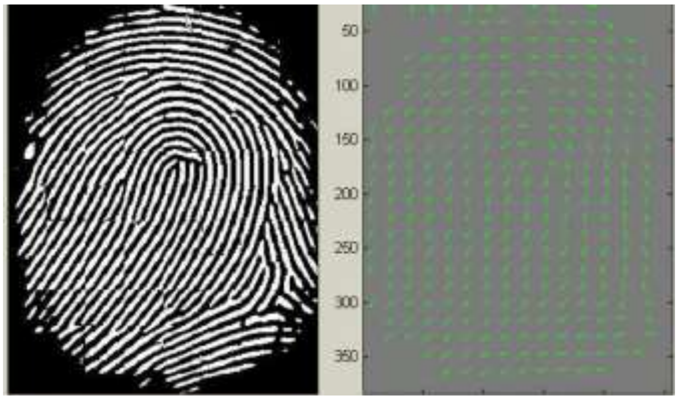

Figure 8: Direction Flow Estimate Binarized Image (Left), Direction Map (Right)

4. MINUTIAE EXTRACTION

4.1 FINGERPRINT RIDGE THINNING

Thinning is the process of reducing binary objects or shapes to strokes whose width is one pixel wide. Here in fingerprint recognition thinning is done to thin the ridges so that each is one pixel thick. In each scan of the fingerprint image, the algorithm removes the redundant pixels in small image window (3x3).In our algorithm, for thinning purposes we had invoked an inbuilt morphological operation in MATLAB.

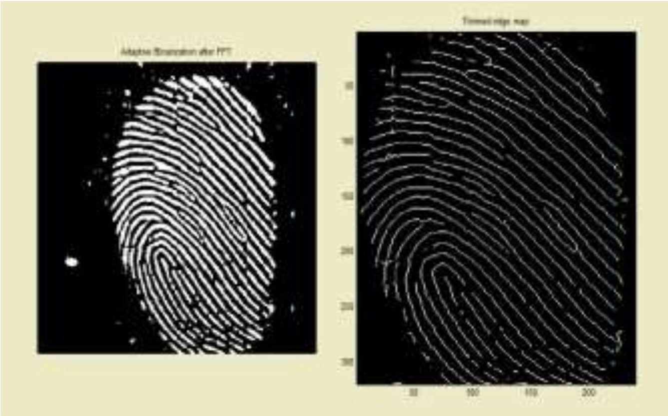

Figure 9: (a) Binarized Image (b) Thinned Ridge Image

4.2 MINUTIA MATCH

The minutia details of two fingerprints are obtained using the above procedures and they are matched using the minutia match algorithm. Alignment based match algorithm is used in our project. It comprises of two stages:

i. Alignment Stage.
ii. Match Stage.

An iterative ridge alignment algorithm is first used to align one set of minutia with respect to another and then an elastic match algorithm is carried out to count the number of matching minutia pairs.

5. SIMULATION RESULTS

This work used fingerprint database which includes fingerprint of 16 persons and each of them with 8 image fingerprint and matching score was obtained in order to compare same image and finally the recognition performance analyzed.

5.1 PERFORMANCE EVALUATION INDEX

To determine the performance of a fingerprint recognition system False Rejection Rate (FRR) is most commonly used as performance evaluation index. Sometimes the biometric security system may incorrectly reject an access attempt by an authorized user. To measure these types of incidents FAR is basically used. A system's FRR basically states the ratio between the number of false rejections and the number of identification attempts.

Mathematically FRR may be expressed in the following manner:

$$(\%)\, FRR = (FR/N) * 100$$

FR=number of incidents of false rejections

N= number of samples

The FRR depends upon the quality of the image whether the quality is good or bad.

We start from first person the database of fingerprint per person is 8 and recognition match 7/8 and percentage of matching is 87.5% but false rejection ratio (FRR) is 1/8 and percentage of FRR is 12.5%. Second person have the same database of fingerprint therefore same percentage matching of FRR result but the third person have database of fingerprint per person is 8 and recognition match 8/8 and FRR is 0/8 thus the percentage of matching 100% and percentage of FRR is 0.0%. The eleventh person has the database of fingerprint 8 and recognition match 6/8 and FRR 2/8 therefore percentage of matching 75.0% and percentage of FRR 25.0%. Overall 16 person weighted average percentage of matching is 89.062% and FRR 10.937%. In the reference [3] the false rejection rate (FRR) is 23.7% due to major variation of finger print ridges depth. . Hence, an overall improvement is 12.76% is achieved in this work. Table 1 showing the FRR and recognition rate of fingerprint matching. Results comparison is shown in table 2.

S. No.	Database Of Fingerprint Per Person	Recognition Match	FRR	% of Matching	% of FRR
1	8	7/8	1/8	87.5%	12.5%
2	8	7/8	1/8	87.5%	12.5%
3	8	8/8	0/8	100.0%	0.0%
4	8	7/8	1/8	87.5%	12.5%
5	8	7/8	1/8	87.5%	12.5%
6	8	7/8	1/8	87.5%	12.5%
7	8	8/8	0/8	100.0%	0.0%
8	8	7/8	1/8	87.5%	12.5%
9	8	7/8	1/8	87.5%	12.5%
10	8	8/8	0/8	100.0%	0.0%
11	8	6/8	2/8	75.0%	25.0%
12	8	8/8	0/8	100.0%	0.0%
13	8	6/8	2/8	75.0%	25.0%
14	8	7/8	1/8	87.5%	12.5%
15	8	7/8	1/8	87.5%	12.5%
16	8	7/8	1/8	87.5%	12.5%
	Weigh Average Percentage			**89.062%**	**10.937 %**

Table 1: Simulation Results Summary

S. No.	Weighted Average Percentage	% of Matching	% of FRR
1.	This Work	**89.062%**	**10.937%**
2.	Reference [3]	76.300%	23.700%

Table 2: Simulation Results Comparison

6. CONCLUSION

This work focuses on image enhancement that include noise reduction, smoothing, contrast stretching, fourier transform and edge enhancement and from that presented a practical performance for minutiae extraction and recognition of the fingerprint images. The matching score of the minutiae was observed to increase at a lower enhancement threshold and by limiting the minimum number of minutiae extracted prior to recognition. These results validate that the collection of image enhancement technique can further improve the recognition rate and matching score by using minutiae extraction. It is believed that further research can be made in producing a better slight image rotation and filtration of unsuitable images that lacking criteria for fingerprint detection.

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