Fingerprint Pre-processing and Features Extraction

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Abstract
Fingerprint is broadly utilized biometric recognizable proof to distinguish the personality of a man due unwavering quality and adequacy. Identification based on biometric is a well-known technique that recognizes identity of a person. Fingerprint identification system contains pre-processing (PP), features extraction (FE) and matching. In this study, we discussed about pre-processing (PP) and features extraction (FE). The pre-processing steps contain in this study are segmentation, normalization, Gabor filter. The main purpose of pre-processing steps is enhancement of fingerprint image. In features extraction we are using thinning and minutiae detection. Experimental results are very encouraging and indicate that fingerprint enhancement and minutiae extraction improves the performance of fingerprint for matching purpose.

Keywords: Biometrics, fingerprint (FP), identification, enhancement, minutiae extraction (ME), Gabor filter (GF), ridge ending, bifurcation

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INTRODUCTION
With the development of access control system, wide range of applications of biometric identification technology are developed, such as recognition of facial, iris, handwriting, fingerprint and speech etc. [1]. Fingerprints are one of the most relevant biometric traits used for biometric recognition. Fingerprints have been used for verifying or identifying an individual for decades [2]. Fingerprint recognition is a well-known biometric identification technology because of lifetime invariance, uniqueness and convenience [3] and, by far, it is the mostly used biometric solution for authentication. Figure 1 shows fingerprint recognition (FPR) system. Biometric distinguishing proof is an outstanding innovation that should be ready to perceive a person’s personality in view of either physical qualities or conduct. Fingerprint is unique and easy to recognize, but there are some challenges in fingerprint scanning such as low quality, incomplete or marked fingerprints create problems that may cause fingerprint system unable to identify the users fingerprint correctly [4].

To overcome these problems, improvement in fingerprint pre-processing steps are proposed and minutiae extraction in this work. The purpose of pre-processing is to enhance the quality of image and also remove unnecessary noise which is followed by FE algorithm that extracts the minutiae features using ridge ending and bifurcation required for matching of different samples.

EXISTING TECHNIQUES
This section is the existence of list of algorithms and tools for enhancement and minutiae extraction. The summarized work is shown in Table 1.

PROPOSED METHODOLOGY
This section presents the proposed framework design for fingerprint enhancement and minutiae extraction. The methodology of this research consists of three major phases. The first is image acquisition. It is then followed by second phase, pre-processing steps and the third phase is minutiae extraction (ME). The block diagram of proposed algorithm is shown in Figure 2.

Image Acquisition
Image acquisition is the first important step before preprocessing because the quality of FP image must be good and noise free. Based on method of acquisition, fingerprint may be live-scan or off-line [3]. Off-line images were
extracted by inked impression of fingertip. Live-scan is done by using optical, UV and capacitive sensors.

**Preprocessing Steps**

The preprocessing phase consists of three major steps include segmentation, normalization and Gabor filter [2, 3].

**Image Segmentation**

Image segmentation is used to locate the boundaries and objects like curves and lines. Image is divided into background and foreground region using threshold. Let V(k) be the variance for a block of size WxW. Then,

\[
V(k) = \frac{1}{W^2} \sum_{i=0}^{W-1} \sum_{j=0}^{W-1} (I(i,j) - M(k))^2
\]

Where, I(i,j) is the grey scale value at pixel (i,j) and M(k) is the mean gray value.

**Normalization**

Normalization is linear process and is done by obtaining grey-level range within the given set of values. The normalized image is given by:

\[
N(i,j) = \begin{align*}
\text{Mo} + \sqrt{Vo} (I(i,j) - M) & \quad \text{if } I(i,j) > M \\
\text{Mo} - \sqrt{Vo} (I(i,j) - M) & \quad \text{otherwise}
\end{align*}
\]

Where, for a pixel I(i,j) the estimated mean and variances are M and V respectively. Mo and Vo denote desired mean and variance values.

**Fig. 1: Block Diagram of Fingerprint Recognition System.**

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Author(s)</th>
<th>Techniques used</th>
<th>Remarks</th>
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</thead>
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<td>Fronthaler et al.</td>
<td>Algorithm for enhancement.</td>
<td>Enhancement make feature detection simple and accurate.</td>
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<td>2</td>
<td>Ravikumar et al.</td>
<td>Segmentation and Gabor wavelets</td>
<td>Fingerprint image quality (FPIQ) enhanced</td>
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<td>3</td>
<td>Hung et al.</td>
<td>Gabor filter(GF)</td>
<td>Better result in goodness index (GI) and verification accuracy</td>
</tr>
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<td>4</td>
<td>Ali Mohm et al.</td>
<td>2-level hierarchical clustering algorithm</td>
<td>Reducing running time</td>
</tr>
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<td>5</td>
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<td>Minutiae matching</td>
<td>FAR is 0.0154, FRR is 0.0137</td>
</tr>
<tr>
<td>6</td>
<td>Alese et al.</td>
<td>Segmentation and thinning</td>
<td>Connectivity of image ridge structure has been preserved</td>
</tr>
<tr>
<td>7</td>
<td>Shlomo et al.</td>
<td>Hist. eq., wiener filter, binarization</td>
<td>Filter show robustness against noise</td>
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<td>8</td>
<td>Wang et al.</td>
<td>Fast FP enhancement algorithm</td>
<td>Improvement in accuracy of minutiae extraction</td>
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<td>9</td>
<td>Jain et al.</td>
<td>Ridge and furrow structure for enhancement</td>
<td>Improvement in GI</td>
</tr>
<tr>
<td>10</td>
<td>Kim et al.</td>
<td>Normalization and Gabor filter (GF)</td>
<td>Improvement in FP image</td>
</tr>
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<td>11</td>
<td>Jian Wei Li et al.</td>
<td>Log-Gabor filter in fingerprint extraction</td>
<td>Improve FPIQ and increase reliability</td>
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<td>12</td>
<td>Jiezhor et al.</td>
<td>Orientation field estimation using dictionary of reference</td>
<td>Better than conventional algorithm</td>
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<td>13</td>
<td>Eryun Liu et al.</td>
<td>ME from level-1 features</td>
<td>Smaller the block size, the higher the minutiae recovering accuracy.</td>
</tr>
<tr>
<td>14</td>
<td>Yao tang et al.</td>
<td>Minutiae extraction using convolutional network</td>
<td>Speed is 0.45 seconds, 53% recall rate, 53% precise rate</td>
</tr>
<tr>
<td>15</td>
<td>Yousra et al.</td>
<td>FPGA based minutiae extraction for FPR</td>
<td>Generates necessary files with parallelism, speed, automatic area minimization</td>
</tr>
<tr>
<td>16</td>
<td>Amor et al.</td>
<td>Discrete cosine transform based FE</td>
<td>Performance is evaluated by k-NN</td>
</tr>
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</table>
**Gabor Filter**

Gabor filter is used for edge detection and is a linear process whose impulse response is the product of harmonic function and Gaussian function [4]. The Gabor filter is represented by:

\[
G(x, y, \Omega, f) = \exp \left\{ 0.5 \times \frac{x^2}{\Omega_x^2} + \frac{y^2}{\Omega_y^2} \right\} \cos(2\pi fx\theta)
\]  

\[X\theta = x \cos\theta + y \sin\theta\]  

\[Y\theta = -x \sin\theta + y \sin\theta\]  

Where, \(\theta\) is the orientation of Gabor filter, \(f\) is the frequency of the wave, \(\Omega_x\) and \(\Omega_y\) are standard deviations of Gaussian function. \(X\theta, Y\theta\) denote \(x\) and \(y\) axes of the filter respectively.

**Features Extraction**

In fingerprint system, there are different methods for feature extraction. Extraction of core and delta, minutiae extraction, extraction of crease, width, shape etc., are different methods which are used. Features extraction based on ridge ending and bifurcation called minutiae points are used in this work. Features extraction steps include thinning and minutiae extraction.

**Thinning**

In binarization, grey scale image is converted into black and white, which is followed by thinning in which is used to remove selected foreground pixels from binary image and eliminate redundant pixels of ridges [3].

**Minutiae Extraction**

Minutiae extraction extracts ridge ending and bifurcation from skeleton images. The method used for minutiae extraction is the crossing number (CN) method. CN is defined as half the sum of the differences between the pairs of adjacent pixel. A 3x3 window is used. The CN is given by:

\[CN=0.5 \sum_{i=1}^{8} (P_i - P_{i+1})\]  

**SIMULATION RESULT**

In this section the experimental results were shown which were performed on the MATLAB software. On the basis of the steps used in proposed methodology, we acquire these results. The images of results according to the steps are shown below in figure3. The below figures shows the changes in the quality of fingerprint that performed for acquiring the following process. The description of each step is described in proposed methodology step.

**CONCLUSION**

In this study, a novel approach for fingerprint minutiae extraction by using ridge ending and bifurcation methods is explained. For Gabor filter, the parameters are set according to the size and quality of image and values can be set according to the requirement of user. We are using different values of parameters of orientation, frequency, standard deviation and getting best result. The best values were found by experimental result 2 as shown in Table 2. Extracted minutiae are clear and accurate for further processing of fingerprint images during the process of recognition. The extracted minutiae were denoted by colored circles. The whole process is very simple and easy to use. The processing time to find minutiae extraction is very less which increase the processing during recognition.
Fingerprint Pre-processing and Features Extraction

(a) Image acquisition
(b) Segmentation of original image
(c) Normalization
(d) Zoomed normalized image
(e) Images after Gabor filtering
(f) Zoomed image of Gabor filter
(g) Image thinning
(h) Zoomed thinning image
(i) Shows the location of minutiae on the fingerprint. To saw the minutiae clearly, the zoomed image as shown in figure (j).

By locating the exact place of minutiae, the graph is represented on the basis of required scale.

Fig. 3: (a) Input Original Image; (b) Segmentation of Original Image; (c, d) Normalization of Input Image and its Zoomed Image; (e, f) Image Obtained from Gabor Filter and its Zoomed Image; (g, h) Thinning Image and Zoomed; (i, j) Minutiae Extracted Image and Zoomed Image to Show the Extracted Points Clearly; (k) Location of Minutiae Without Showing Ridges and Valleys.

Table 2: Different Values of Parameters for Gabor Filter Performed Different Experimental Values.

<table>
<thead>
<tr>
<th>Parameters/values</th>
<th>Exp. Value 1</th>
<th>Exp. Value 2</th>
<th>Exp. Value 3</th>
<th>Exp. Value 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower range, a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Upper range, b</td>
<td>255</td>
<td>130</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Alpha, al</td>
<td>0.3</td>
<td>0.3</td>
<td>0.25</td>
<td>0.3</td>
</tr>
<tr>
<td>Beta, be</td>
<td>2.5</td>
<td>1.414</td>
<td>1.414</td>
<td>1.8</td>
</tr>
<tr>
<td>Gamma, ga</td>
<td>3.6</td>
<td>1.414</td>
<td>1.414</td>
<td>1.8</td>
</tr>
</tbody>
</table>

REFERENCES
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enhancement and minutiae extraction algorithm, Sweden. Date: 2016-05-31

Cite this Article