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Fingerprint Minutiae Identification Using RLC Method

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Abstract— This paper is aimed to design a scheme to mark and extract minutiae of fingerprint using Run-length Coding technique. Minutiae extraction takes vital role in fingerprint based authentication and identifications systems. The scheme comprises of binarization, thinning, minutia marking and extraction. The scheme is tested using the FVC database and real time fingerprint datasets. The Experimental results are presented.

Keywords— fingerprint, minutiae, filter, preprocessing, binarization, thinning, Gabor.

I. Introduction

The correctness of the fingerprint matching process depends on the feature extraction phase. This paper follows the RLC (Run-Length Code) based method for the minutiae extraction. The Human fingerprint consists of various types of features that are the ridge patterns, traditionally classified according to the decade's old Hendry system: Left loop, Right loop, Arch, Whorl and Tented arch. Fingerprint features are classified into three levels. Level 1 Features are: Arch, Tented arch, Right loop, Left loop, double loop and Whorl. The Level 2 features are Line-unit, Line-fragment, Ending, Bifurcation, Eye and Hook. The Level 3 features are Pores, line shape, incipient ridges, creases, warts and scars [1]. The level 2 features are having adequate sharp power, used to establish the individuality of fingerprint [2].

II. Related Work

Feature extraction techniques are classified in to different ways; According to image: Direct gray level minutiae extraction, Binary minutiae extraction; According to Levels of features: Level 1 feature extraction, Level 2 feature extraction, Level 3 feature extraction. The author desires to extract Binary fingerprint- Level 2 features which possess an adequate and sharp power. Yet other feature extraction techniques are surveyed. They are:

- Orientation or Directional Mapping method
- Gabor-Filter Bank and Orientation method
- Run-Length Coding method
- Chain Code method
- Crossing Number method
- Morphology based method

Run-Length Coding (RLC) method [3], [4] is effective when long sequence of the same symbol occurs. RLC uses the Scan line procedure to extract features. Nalini K. Ratha et al. [5] designed an adaptive flow orientation based feature extraction method to extract binary fingerprint features and also used a waveform projection based ridge segmentation algorithm to locate ridges accurately. Chih-Jen Lee et al. [6] proposed a Gabor-Filter based method for fingerprint recognition. The Gabor-filter based features can also be used for the process of local ridge orientation, core point detection and features extraction. Jain et al. [7] suggested the multichannel approach using Gabor filter for the classification of fingerprints features. Wan S [8] proposed a method based on directional fields of fingerprint image to detect the singular points (cores) and extract features.

Neil Yager [9] distinguished the fingerprint features in to different classes. Orientations fields and Gabor-filtering are influential means for classifications of fingerprints features. Classifications and identification of fingerprint features are used for the recognition and features extraction. SharatChikkerur et al. [10] proposed an approach of Orientation Map for fingerprint image feature extraction. Feng Zhoo et al. [11] used Crossing Number (CN) method to extract minutiae from the Valley skeleton binary image. The Orientation Maps and Gabor filters are good in fingerprint feature extraction [12]. The research work proposes a hybrid approach based on Log-Gabor Orientation with RLC method to get accurate minutiae.

III. Procedure For Minutiae Extraction Scheme

The procedure includes three main stages: Image preprocessing cum Enhancement,Minutia Marking and

Minutia Extraction. The System level design is shown in figure 1.

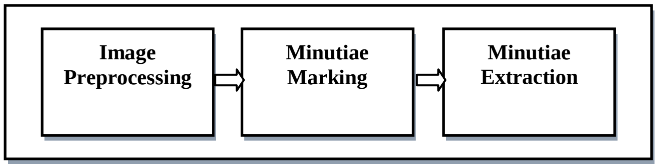

Figure 1 System Level design of the Minutia Extraction Scheme

Preprocessing

The preprocessing stage includes the Fourier Transformation and the filtering using Log-Gabor Filter followed by Binarization as discussed in chapter 5. Steps followed in the first stage are described below.

1) Image Acquisition

The first step of the procedure is the image acquisition. The images are acquired from benchmark data sets and also real time fingerprint images.

2) Image Preprocessing

Table 1. Pixels of N (P)

x_4	x_3	x_2
x_5	P	x_1
x_6	x_7	x_8

The image enhancement can be carried out in either spatial or frequency domain. The frequency domain enhancement is carried out for the succeeding work. The frequency values are obtained through the Fast Fourier Transformation. It transforms the image into a frequency image; and the image is enhanced with Log-Gabor filtering technique.

1) Binarization

After having the Log-Gabor enhanced image, the binarization is carried out. Binarization is the process of converting the gray-level image [0-255] to binary image [0 or 1]. New value (0 or 1) can be assigned for each pixel according to the intensity mean in a local neighborhood, as follows:

$$I_{new}(p1,p2) = \begin{cases} \mathbf{1} \boldsymbol{if} \boldsymbol{I}_{\boldsymbol{old}(\boldsymbol{p1},\boldsymbol{p2} \geq \boldsymbol{localMean})} \\ \mathbf{0} \boldsymbol{otherwise} \end{cases} \quad (1)$$

The gray-scale transformations do not depend on the position of the pixel in the image. During the binarization process, the low frequency pixels are omitted. For the binarization process, the Log-Gabor filtered image is used.

2) Image Enhancement

Before extracting minutiae, the fingerprint image is enhanced to get compatible patterns of features. This stage includes three main steps: Thinning, Minutiae Marking (FOI: Feature of Interest) and Extracting minutiae sets. These steps are described in the next sections.

3) Thinning

In order to get skeleton of the fingerprint image, thinning process is followed. A skeleton is a one-pixel wide ridge [13]. Thinning is a process of translating the thickness of an image into one pixel width representation. From thinning process, thinned and sharp ridges of fingerprint features are derived. It gives a clear structure of the fingerprint image. The thin operation uses the following algorithm [14].

Step 1: Divide the image into two distinct subfields in a checkerboard pattern.

Step 2: Delete pixel p from the first subfield if and only if the conditions G1, G2, and G3 are all satisfied in the first iteration.

Step 3: Delete pixel p from the second subfield if and only if the conditions G1, G2 and G3` are all satisfied during the second sub- iteration.

***Condition G1*:**

$$X_H(P) = 1 \quad (2)$$

where$X_H(P) = \sum_{i=1}^{4} bi$

$$b_i = \begin{cases} 1, if\, x_{2i-1} = 0 \; and (x_{2i=1} \; or x_{2i+1} = 1) \\ 0, \quad otherwise. \end{cases}$$

where$x_1, x_2, \ldots, x_8$ are the values of the eight neighbors of p, starting with the least neighbor and numbered n counter-clockwise order. Figure2 shows the neighbors of p in a checkerboard format.

***Condition G2*:**

$$\mathbf{2 \leq min\{n1(p), n2(p)\} \leq 3} \quad (3)$$

Where $n1(p) = \sum_{i=1}^{4} x_{2k-1} \vee x_{2k}$ (4)

$$\boldsymbol{n2(p) = \sum_{i=1}^{4} x_{2k} \vee x_{2k+1}} \quad (5)$$

Condition G3:

$$\mathbf{G3:}(\boldsymbol{x_2 \vee x_3 \vee \overline{x_8}}) \wedge \boldsymbol{x_1} = \mathbf{0} \quad (6)$$

G3 is in the first sub-iteration.

***Condition G3`*:**

$$\boldsymbol{G3`:} (\boldsymbol{x_6 \vee x_7 \vee \overline{x_4}}) \wedge \boldsymbol{x_5} = \mathbf{0} \quad (7)$$

G3`: 180^o rotation in the second.

The given two subscriptions together make an iteration of the thinning algorithm. These iterations are repeated until the specified time. It is set as infinite number of iterations (n='inf'). Therefore, the iterations are repeated until the image stops changing. The conditions are all tested using the pre-computed look up tables.

1) Minutia Marking

In this research work, Level 2 features: Terminations and Bifurcations are used to extract. Features are marked using labeling technique and also Run-length Coding algorithm. The algorithm to find the minutiae is given below.

Step1: Run-Length encoding the input image (RLE).

Step 2: Scan the runs; assigning preliminary labels for connected components in binary image.
Step 3: Determine the equivalence classes(c).
Step 4: Concatenate all relevant classes.
Step 5: Re-label the runs based on the determined equivalence classes (LB(c)).

Marking or Labeling of connected components is one of the most main operations in pattern recognition. It is essential when an object gets recognized [15]. The proposed algorithm includes scanning, labeling, and determine the equivalence classes of minutiae in order to group and concatenate the relevant classes.

The minutiae extraction uses the skeleton image where the ridge flow is 8-connected. The minutiae which are marked (labeled) by scanning the local neighborhood of each ridge pixels in the fingerprint image using (3×3) non-overlapping windows. Based on the label values LB, the ridge pixels are classified into Terminations and Bifurcations. If the pixel is labeled with 0 then it is determined as Isolation. If the pixel is labeled with 1, 2 then it is determined as Termination and Continuing Terminations respectively; and if the pixel is labeled as 3, 4 then it is determined as Bifurcation, Crossing respectively as furnished in Table 2. The templates of Termination and bifucaptions are shown in figures 3. The row1 of the figure points up the single point (Isolation points) of the fingerprint. Row 2 shows the Terminations with two minutiae of fingerprint. Row3 reflects the continuing terminations of a fingerprint; row 4 indicates the bifurcations and row 5 points up the crossing of neighbor points of fingerprint minutiae.

Table 2. Property of the Label

Label (LB)	Property
0	Isolation
1	Termination
2	Continuing Termination
3	Bifurcation
4	Crossing Point

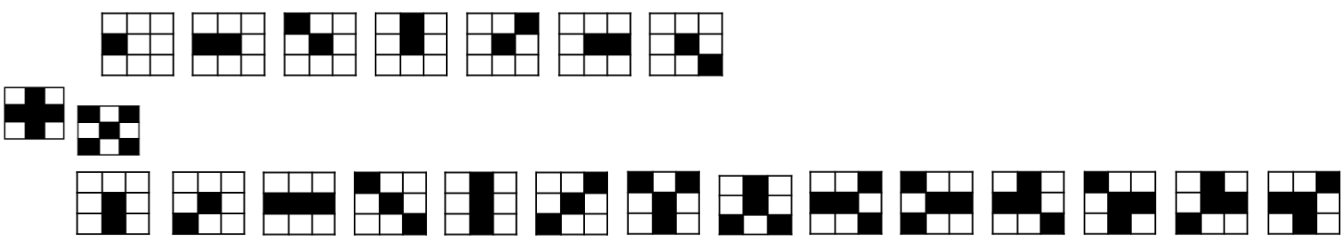

Figure 3 Templates of Isolation (Row 1), Terminations (Row 2), and Continuing Terminations (Row 3), Bifurcations (Row 4), and Crossing (Row 5).

A. Minutiae Extraction

Minutiae extraction depends on the labels and properties of the marked minutiae (as defined in table 1). Based on the properties, the ridge terminations and bifurcations are extracted from the fingerprint image as shown in figure 4. The circle refers the ridge endings and the square refers the ridge bifurcations.

IV. Experimental Results and Discussion

The experimental results are shown in figure. 4. The results show the while extracting minutia. From the first step, fingerprint image is captured and then preprocessing stage is carried out; in this stage, the frequency domain enhancement is followed in order to get frequency value.

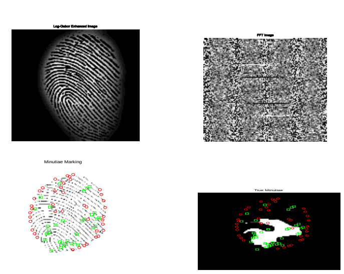

Figure 4 Minutiae Extraction stages: (a)Origianl image (b) FFT Image (c) Log-Gabor filterd image (d) Minutiae Marking on thinned image, (e) Minutiae Extraction.

In the second stage, minutia extraction is performed. Finally, the true minutiae set are obtained.

V. CONCLUSION

The Minutiae extraction scheme is implemented in order to achieve dual purpose tasks; these are an enhancement cum minutiae feature extraction through the Log-Gabor orientation and RLC methods. Enhanced minutiae are extracted for further process.

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Dr. K. Kanagalakshmi is working as an Associate Professor and Head in Department of Computer Applications in Nehru Arts and Science College, Coimbatore, Tamilnadu. She is having 17 years of teaching experience. She has published more than 15 research papers in International Journals and presented more than 65 papers in International, National and State level Seminars, Conferences together. Her areas of interest include Biometric, Pattern Recognition, Digital Image Processing, Security etc. She has produced more than 5 M.Phil. Scholars and she is guiding 8 Ph.D. Scholars. She has published 4 books. She is an Associate member of CSI.

