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Performance Analysis of Fingerprint Based Image Enhancement and Minutiae Extraction

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Abstract- Extracting minutiae from fingerprint images is one of the most important steps in automatic fingerprint identification and classification. Minutiae are local discontinuities in the fingerprint pattern, mainly terminations and bifurcations. In this work we have propose a method for fingerprint image enhancement. Using histogram equalization over filtering and then minutia are calculated. The results achieved are compared with those obtained through some other methods. The Results show some improvement in the minutiae extraction in terms of quantity.

Keywords: Fingerprint, Image enhancement, Filtering, Minutiae extraction

I. INTRODUCTION

Fingerprints are today the most widely used biometric features for personal identification. Most automatic systems for fingerprint comparison are based on minutiae extraction [3]. Minutiae characteristics are local discontinuities in the fingerprint pattern which represent terminations and bifurcations. A ridge termination is defined as the point where a ridge ends abruptly. A ridge bifurcation is defined as the point where a ridge forks or diverges into branch ridges (Fig. 1). Reliable automatic extracting of minutiae is a critical step in fingerprint classification. The quality of minutia extracted depends upon the quality of the image , ridge structures in fingerprint images are not always well defined, and therefore, an enhancement algorithm, which can improve the clarity of the ridge structures, is necessary [4]. This work proposes three methods for fingerprint image enhancement. The first one is carried out using image adjust and stretch technique. The second method uses local histogram equalization and the third method uses histogram equalization over filtering for direct grayscale enhancement. Section 2 addresses the basics of these approaches. Section 3 addresses the main steps of minutia extraction. In this section we will first load the image then we will apply the enhancement algorithm discussed in section 2. Then finalization process is applied by adaptive thresholding Thinning is then carried out which provides good results on fingerprints then morphological filtering is applied to calculate the bifurcation and termination and finally we will process the spurious minutia based on the distance comparison method .

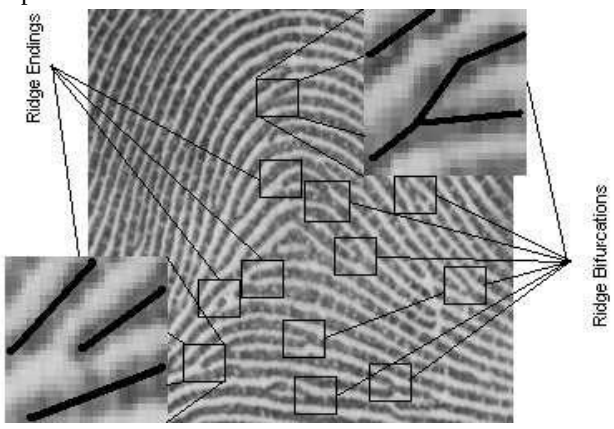


Figure 1. Fingerprint image with Ridge Bifurcation and Ridge Termination

II. IMAGE ENHANCEMENT ALGORITHM

2.1 Linear Contrast Stretching

Intensity mapping can be used to enhance contrast. The idea is to stretch out the intensity values to a wider range:

$$g = \left(f - a \middle/ b - a \right)(d - c) + c$$

Where f and g are the input and output intensity values respectively; a to b is the original intensity range; and c to d is the stretched out range. In IPT, intensity mapping is supported by function imadjust

2. 2. Histogram Equalization

Histogram equalization is to expand the pixel value distribution of an image so as to increase the perceptional information. The original histogram of a fingerprint image has the bimodal type [Figure histogram, original], the histogram after the histogram equalization occupies all the range from 0 to 255 and the visualization effect is enhanced [Figure histogram, equalized].

The goal of histogram equalization is to spread out the contrast of a given image evenly throughout the entire available dynamic range, in this case between 0 and 1.

In histogram equalization technique, it is the probability density function (pdf) that is being manipulated. To make it simple, what histogram equalization technique does is that, it changes the pdf of a given image into that of a uniform pdf that spreads out from the lowest pixel value (0 in this case) to the highest pixel value (L – 1). This can be achieved quite easily if the pdf is a continuous function. However, since we are dealing with a digital image, the pdf will be a discrete function. Let suppose we have an image x, and let the dynamic range for the intensity rk varies from 0 (black) to L – 1 (white). This pdf can be approximated using the probability based on the histogram $p(r_k)$ as follows

$$pdf(x) = p(r_k) = \frac{total \text{ pixels with intensity } r_k}{toal \text{ pixels in image x}} \qquad \text{Eq(1)}$$

From this pdf, we can then obtain the cumulative density function (cdf) as follows:

$$cdf(x) = \sum_{k=0}^{L-1} p(r_k) \qquad \text{Eq (2)}$$

The output pixels from the histogram equalization operation is then equals to the cdf of the image or mathematically

$$p(s_k) = \sum_{k=0}^{L-1} p(r_k) \qquad \text{Eq (3)}$$

To get the value of the pixel, $p(s_k)$ need to be multiplied by $L - 1$ and then round it to the nearest integer.

2.3 Histogram equalization over noise reduction

In this approach first Histogram equalization is done then median filtering is applied to reduce the noise. Neighborhood averaging can suppress isolated out-of-range noise, but the side effect is that it also blurs sudden changes (corresponding to high spatial frequencies) such as sharp edges. The *median filter* is an effective method that can suppress isolated noise without blurring sharp edges. Specifically, the median filter replaces a pixel by the median of all pixels in the neighborhood:

$$y[m,n] = median\{x[i,j], (i,j) \in w\}$$

Where w represents a neighborhood centered on location (mm, n) in the image.

III. SIMULATION DESIGN AND IMPLEMENTATION DETAILS

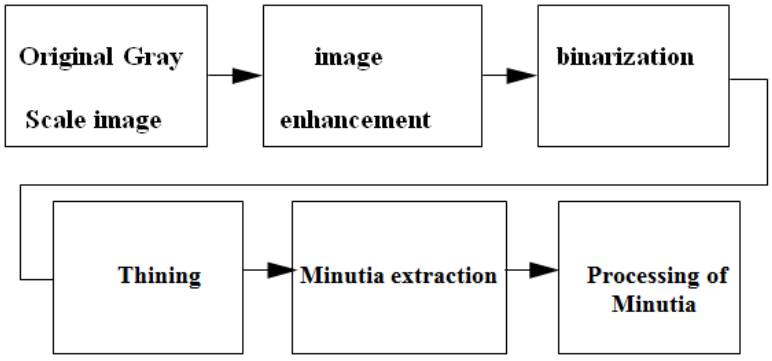


Figure 2. Process of Minutia Calculation

3.1 Fingerprint image used for the experiments

fingure1

Figure 3. Initial fingerprint image on which all the operations are performed

3.2 Image Enhancement

A critical step in automatic fingerprint matching is to automatically and reliably extract minutiae from the input fingerprint images. However, the performance of a minutiae extraction algorithm relies heavily on the quality of the input fingerprint images. I have already described in section 2 about the image enhancement techniques.

3.3 binrization

The operation that converts a grayscale image into a binary image is known as binarization. We carried out the binarization process using an adaptive thresholding. Each pixel is assigned a new value (1 or 0) according to the intensity mean in a local neighborhood:

3.4 Thining

Ridge thinning is to eliminate the redundant pixels of ridges till the ridges are just one pixel wide.

3.5 Minutiae Extraction

The most commonly employed method of minutiae extraction is the Crossing Number (CN) concept [1, 2,]. This method involves the use of the skeleton image where the ridge flow pattern is eight-connected. The minutiae are extracted by scanning the local neighborhood of each ridge pixel in the image using a 3*X*3 window. The CN value is then computed, which is defined as half the sum of the differences between pairs of adjacent pixels in the eight-neighborhood. Using the properties of the CN as shown in Table 1, the ridge pixel can then be classified as a ridge ending, bifurcation or non-minutiae point.

Table 1: Properties of the Crossing Number

0	Isolated points
1	Ridge ending point
2	Continuing ridge point
3	Bifurcation point
4	Crossing point

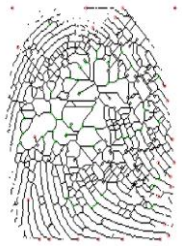
3.6 processing of spurious Minutia

In this part spurious minutiae are processed and deleted. On the bases of distance between a termination and a bifurcation from a number D.

IV. RESULTS AND DISCUSSION

4.1 Calculation of Minutia Extraction after applying Linear Contrast Stretching (Image adjustment and stretch method)

Finger 2

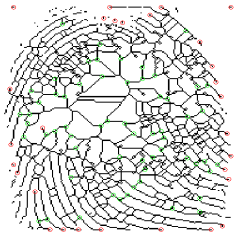


minutia image

Figure 4. Enhanced image finger 2 and its minutia image after applying contrast stretching

4.2 Calculation of Minutia Extraction after applying Histogram Equalization

Finger 3



minutia image

Figure 5. Enhanced image finger 3 and its minutia image after applying Histogram Equalization

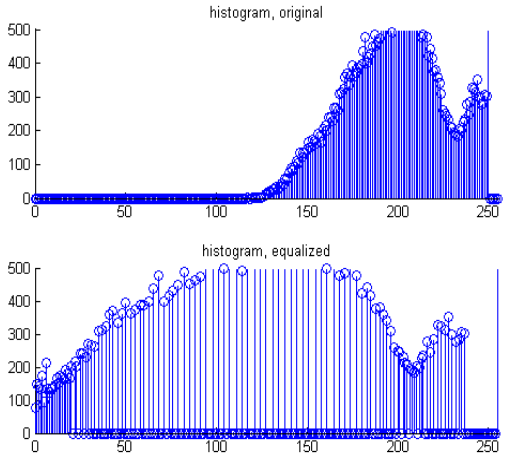


Figure 6. Histogram before and after Histogram Equalized

4.3 Calculation of Minutia Extraction after applying Histogram Equalization over filtering

Finger 4

minutia image

Table 5.2: Minutia Calculation after applying different image enhancement technique

Minutia Calculation			
Image Processing Technique	**Number of termination (Red Colored)**	**Number of bifurcation (Green colored)**	**Total No. of Minutia Calculated**
1. Linear Contrast Stretching	**25**	**44**	**69**
2.Histogram Equalization	**29**	**61**	**90**
3.Histogram Equalization over filtering	**33**	**67**	**100**

The results presented in this section demonstrate that, within the simulation framework presented above, the minutia extracted after the Histogram equalization over filtering is substantially higher. These results recommend that, Histogram equalization over filtering can be used for minutia extraction and further for Minutia Matching.

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