

Tangent Direction Computation in Ridge Line Following of Gray Scale Fingerprint Images

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Abstract –Most Automatic Fingerprint Identification System (AFIS) is based on minutiae matching due to its uniqueness. Minutiae are essentially terminations and bifurcations of the ridge lines that constitute a fingerprint pattern. Maio and Maltoni (1997) proposed a method to detect minutiae in gray scale fingerprint images based on ridge line following which is to trail the ridge line according to the fingerprint directional image. In order to determine the direction of the ridges, computation of tangent direction is a must. Maio and Maltoni applied least-squared minimization technique to obtain the tangent direction. In this paper, we implement Sobel mask technique as an alternative to least-square minimization.

Key words : tangent direction, ridge line following, gray scale images, minutiae detection, Automatic Fingerprint Identification System (AFIS).

I INTRODUCTION

Fingerprint-based identification has been known and used for a very long time. The fingerprint image contains narrow ridges separated by narrow background valleys. Automatic fingerprint system consists of two types: identification and verification system. Fingerprint identification system is also called as "one-to-many" search, where a fingerprint of an unknown person is compared against database to determine his or hers identity. Whereas, fingerprint verification system which is also called as "one-to-one" search differs from fingerprint identification system, positively identifying an individual on demand. In this case, one have to identify himself by key-in identification number or pin card number as well as his fingerprint serves as the identifier to prove to the system that the person is really who he or she claim to be. The similarity between these two systems is it's based on minutiae location (x,y) and direction in order to make the comparison between the fingerprint sample from the person and in the database.

Basically, there are 18 different types of minutiae [1]. Ridge ending and ridge bifurcation are two minutiae needed in most automatic fingerprint identification system. Typically, a rolled thumbprint will have about 50 to 60 minutiae while a normal impression has 20 to 30 [2]. Each minutiae point faces a particular direction. This direction of the minutiae is assigned as the direction of the ridges, which this minutiae is on. The position, type and orientation of each minutiae are recorded for identification or verification.

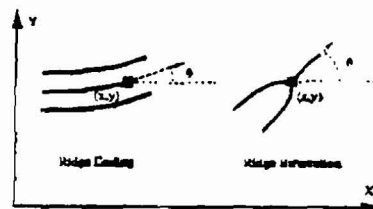


Figure 1: Position and orientations of a bifurcation and ridge ending

II RIDGE LINE FOLLOWING

The basic idea of ridge line following is to trail the ridge line according to the fingerprint directional image (Figure 2). In 1992, ridge line following was applied to binary fingerprint image for thinning process [2]. Maio and Maltoni used the same algorithm and apply it to gray scale images to detect the minutiae [3]. A set of starting point is determined by superimposing a square-meshed grid on the gray scale image. For each starting point, the algorithm keeps following the ridge lines until they terminate or intersect other ridge line.

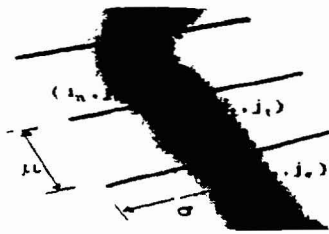


Figure 2. Steps of ridge line following

III TANGENT DIRECTION

In order to determine the next point on the ridges, computation of tangent direction is a must. Maio and Maltoni used a technique proposed by Donahue and Rokhlin [4] in determining the tangent direction. The experimental results obtained by them have shown that errors still occur and most of it are due to minutiae exchanges (i.e. termination minutiae are detected as bifurcation minutiae and vice versa). In order to overcome this problem, we applied Sobel mask as an alternative in computing tangent direction.

According to technique proposed by Donahue and Rokhlin, the tangent direction is determined by least-squares minimization over the surface normals (calculated for each 2×2 pixel neighborhood) in an averaging window [3,4]. The surface normal is refer as vector $n_{hk} = (n_1, n_2, 1)$ which is parallel to z-axis (perpendicular to image plane), obtained from each pixel in tangent window (squared window centered in (x_0, y_0) with length of u pixels) ($h = 1..u, k = 1..u$). Then, the average tangent vector which refer to tangent direction $t(t_1, t_2)$ is determined as the unit vector lying on the ij -plane which is most perpendicular to all the normal vectors n_{hk} computed over the tangent window [4].

In spite of technique proposed by Donahue and Rokhlin, tangent direction could also be computed using Sobel operator. Sobel operator has been widely used in feature extraction, orientation and edge direction. The Sobel operator gives good approximation of gradient value (G_x and G_y) for each pixel (x, y) in sized window of 3×3 . The gradient values then will be used for local orientation estimation of each block centered at pixel (x, y) using the following equations :

$$V_x(i, j) = \sum_{u=i-\frac{W}{2}}^{i+\frac{W}{2}} \sum_{v=j-\frac{W}{2}}^{j+\frac{W}{2}} 2G_x(u, v)G_y(u, v)$$

$$V_y(i, j) = \sum_{u=i-\frac{W}{2}}^{i+\frac{W}{2}} \sum_{v=j-\frac{W}{2}}^{j+\frac{W}{2}} (G_x^2(u, v) - G_y^2(u, v))$$

$$\theta(i, j) = \frac{1}{2} \tan^{-1} \left(\frac{V_x(i, j)}{V_y(i, j)} \right)$$

IV EXPERIMENTS AND RESULTS

Both techniques have been applied to gray scale fingerprint images sized 256×256 . Ten fingerprint images are taken for each class. Few starting points have been taken in gray scale fingerprint images and tangent direction was calculated to obtain the direction of ridges. The percentage of accuracy is shown in Table 1.

Table 1 : Average Accuracy Percentage of Tangent Direction Calculation

Class Fingerprint	Average Accuracy Percentage	
	Donahue & Rokhlin Technique	Sobel Mask Technique
Loop	67	53
Whorl	55	74
Arch	80	65

Technique proposed by Donahue and Rokhlin is well performed in arch class fingerprint. Whereas Sobel Mask technique gives a good result in whorl class fingerprint. For loop class fingerprint, Donahue and Rokhlins' technique gives a better result of accuracy.

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