Rotation-invariant Reference Point Location Detection Using Complex Filtering for Fingerprint Matching

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***Abstract*-Filterbank-based fingerprint matching algorithm is able to capture minutiae information in a fingerprint. However, this method's accuracy is highly dependent on the algorithm's ability to detect the reference point accurately. In this paper, a new algorithm is proposed to locate the reference point of the fingerprint based on the rotation-invariant reference point location. It is used alongside with the Filterbank-based fingerprint matching algorithm to locate the reference point of fingerprint. The optimum values for the number of bands (B), the number of sectors per band (k), and the number of Gabor filters to produce the best result is also calculated. The results prove to be conclusive.**

***Index Terms*—biometric, fingerprint recognition, gabor filter, complex filtering, rotation-invariant reference point.**

I. Introduction

A fingerprint is defined as the pattern of ridges found on the surface of one's fingertips. A fingerprint consists of ridges (raised skin) and a core point (the northernmost point of the innermost ridge) [2]. When analyzed, an important feature of the fingerprint called the minutiae can be found. The minutiae include features like ridge bifurcation (a ridge that further divides two ridges), curvature and termination. These regions are collectively known as singularities and are further divided into three topologies: loop, delta, and whorl [2].

II. Filterbank-based Algorithm

A number of fingerprint matching techniques have been developed; they include point-based, graph-based, and string-based matching. Minutiae based matching, while sufficient, does not fully utilize all the features available in a finger print. It is also unreliable when attempting to compare two fingerprints with different amount of minutiae.

Gabor filters have been used by Jain et al. [3] in a filter-based matching algorithm. These filters can capture minutiae details and global ridge patterns and compress them into a single fixed-length FingerCode [1]. Using Euclidean distance, the FingerCode is compared with a series of finger prints contained in a database.

A. Problem Formation

Although the original Filterbank based algorithm produces a better result than other fingerprint recognition systems, the fingerprint's position is assumed to be vertical. Despite the accuracy of the original reference location method on vertical fingerprints, it is unable to accurately detect the core reference point on the rotated images. Therefore, it is suggested that another algorithm be used together to locate the core point on rotated images.

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III. Reference Point Location Detection Using Complex Filtering

Due to the importance of locating the reference point on fingerprints image, the core points must be consistently located for all types of fingerprints.

The rotation-invariant reference point location detection (RIRPLD) method is a reliable algorithm for reference point detection using complex filtering method [4]. Complex filters, of order m, can be modeled by where i is the imaginary unit, m is an integer and φ is the orientation angle [5]. Using polynomial approximation on these complex filters produces; here g is a Gaussian defined as below and x and y are the coordinates [6].

$$g(x,y) = \exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \tag{1}$$

Core pattern and delta pattern are two kinds of orientation patterns in fingerprint images. The complex filter response is formulated as, μ represents the degree of symmetry; α is the geometric orientation of the symmetric pattern [18]. If |μ1| >T1, the fingerprint is the core type. If |μ2| >T2, then it is type delta [6]. The magnitude response of the filter is sharpened using the following rules, where k = 0,1,2,3 [6].

$$\begin{aligned} S_{1k} &= \mu_{1k}(1-\mu_{2k}) \\ S_{2k} &= \mu_{2k}(1-\mu_{1k}) \end{aligned} \tag{2}$$

To implement this algorithm, the scalar product (h,z) is then calculated; we use the following equation to obtain h, where h indicates the complex filter order m, and z is the complex orientation field [6].

$$h = (x+iy)^m g(x,y) \tag{3}$$

IV. Results and Discussions

By using the complex filtering algorithm, 125 sample fingerprints from the Fingerprint Verification Competition 2000 (FVC2000) db1_a database were used to examine on the effect of the number of bands (B), the number of sectors in each band (k), and the number of Gabor filters and obtain to the corresponding equal error.

From Table I, it can be seen that higher number of bands tends to produce a higher error rate. This is due to the fact that bigger areas are needed for higher number of bands. Each band has to be set to 20-pixels wide to capture a minutia for each sector [1]. So, for 4, 5 and 7 bands, the minimum size of the region of interest should be 187×187, 227×227, and 307×307 respectively.

TABLE I: NUMBER OF BAND, SECTORS PER BAND AND NUMBER OF GABOR FILTERS TO THE EQUAL ERROR RATE.

No of band, B	Sector per band, k	Total sector, (B*k)	No. of Gabor filter, G	Equal error rate, %
4	16	64	8	9
5	16	80	8	5
7	16	112	8	12
4	32	128	8	10
5	32	160	8	11
7	32	224	8	14
4	16	64	16	10
5	16	80	16	10
7	16	112	16	17

From the table 1, 5 bands produce the optimum results, since the region of interest of the size 227 × 227 could be cropped around the core center of most of the fingerprint images while it is hard to crop the region of interest of size 307 × 307 since the size of the input images are just 388 × 374. Figure 8 shows the comparison between the original fingerprint images, and regions of interest of band 4, 5, and 7 respectively. For band 7, the region around the core point is smaller than 307 × 307 and the black area indicates the empty area which represents no information. Unless a larger input fingerprint image is used, 7 bands are redundant and will produce more error.

V. CONCLUSIONS

Filterbank-based fingerprint recognition system uses information present in the minutiae to verify an individual. A fingerprint's core point is established and the area around it filtered. Euclidean distance is calculated and it is then compared to a database of finger prints. The closest fingerprint within the cutoff threshold is deemed the match. However, one of the Filterbank method's weaknesses is its inability to detect the core point in rotated images. Using a complex filtering algorithm on rotated images, the rotation-invariant reference point location algorithm is capable of accurately detecting the core point. Setting the number of band to 5, 16 sectors per band and 8 Gabor filters, the optimum system is achieved with equal error rate of only 5%.

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