

FINGERPRINT VERIFICATION USING WAVELET AND LOCAL DOMINANT ORIENTATION

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ABSTRACT

This paper describes the fingerprint verification based on wavelet transform and the local dominant orientation. Daubechies wavelet is use to decompose the fingerprint image. The local dominant orientation is computed using the coherence. The trainee and test fingerprint images are aligned around core point, in this paper the core point is detected as a maximum curvature point. We received 85 percent genuine acceptance rate at 6 percent false acceptance rate (FAR).

KEY WORDS

Wavelet transform, verification, coherence, orientation

1. Introduction

Among all the biometric, fingerprint have highest reliability and have been extensively used by forensic experts in criminal investigations. Fingerprints are believed to be unique across individuals, and across fingers of the same individual [1]. Even identical twins having similar DNA, are believed to have different fingerprints. Because of this there is increased use of automatic fingerprint verification systems in civilian as well as in law-enforcement applications. Fingerprint matching techniques can be broadly classified as minutiae-based and image based.

A minutia-based technique aligns the two sets of minutiae points and determines the total number of matched minutiae [2]. Unfortunately the minutiae-based approach contains many time-consuming steps and relies heavily on the quality of input images. In fingerprint images, however, minutiae are not always clear even though the information of ridge directions and inter-ridge distances is preserved.

The use of Gabor filter for texture classification and feature extraction have been proved its importance. Due to the multi-resolution capacity of Gabor transform it retains the textural features of a image. Numbers of

methods to find the unique features from the output of Gabor filter have been discussed and compared [3]. To avoid the drawbacks of minutiae based fingerprint verification system; the image-based fingerprint verification system has been described in which feature are extracted by using a bank of Gabor filters [4]. A hybrid fingerprint-matching scheme has been described [5], in which a minutiae-based and image-based algorithms are combined to find the combined matching score [5].

We present an algorithm for fingerprint verification based on image-based technique. The local ridge characteristics of a fingerprint image are represented by using directional information of wavelet and local dominant direction.

Clearly explain the nature of the problem, previous work, purpose, and contribution of the paper.

2. Wavelet Transform

The Discrete wavelet transform is identical to a hierarchical sub band system where the sub-bands are logarithmically spaced in frequency and represent octave-band decomposition [6].

Wavelets provide rich techniques that can be applied to many tasks in signal processing, and therefore have numerous potential applications [7]. In this paper, symmetric wavelet is used which is; modified version of Daubechies' wavelet.

The figures shown below (in Fig. 1) show the results of wavelet transform of fingerprint image. The figures show the directional characteristics of wavelets very clearly. Precisely, the LH band represents vertical information. Similarly, the HL band reflects the horizontal characteristics very well and the LL band shows overall information of the original fingerprint.

3. Feature Extraction

Directional information obtained from wavelets does not represent all directions. Consequently, we can not use

them directly as the feature vectors to represent a given fingerprint. We need a feature vector, which describes more detailed directional information contained in fingerprint. To satisfy this, gradient of Gaussian and coherence is applied to wavelet [8].

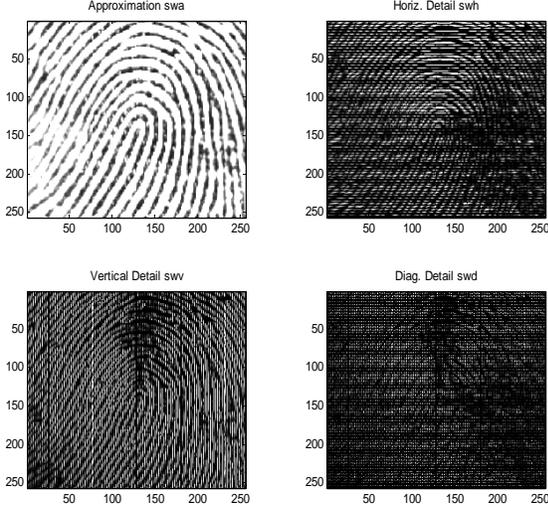


Fig.1. Wavelet Decomposed Fingerprint

Gradient G_{mn} , and corresponding angle θ_{mn} at the position (m, n) are defined as

$$G_{mn} = M \times (|G_{mn}^x| + |G_{mn}^y|)$$

$$\theta_{mn} = \tan^{-1} \left[\frac{G_{mn}^y}{G_{mn}^x} \right] \quad \text{-----(1)}$$

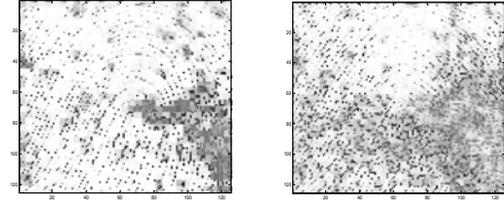
The quantities G_{mn}^x and G_{mn}^y represent the components of G_{mn} in horizontal and vertical directions, respectively. Once G_{mn} and θ_{mn} , are obtained, the coherence is computed [9] next. The coherence ρ_{mn} is defined as

$$\rho_{mn} = \frac{\sum_{(i,j) \in w} G_{ij} \cos(\theta_{mn} - \theta_{ij})}{\sum_{(i,j) \in w} G_{ij}} \quad \text{-----(2)}$$

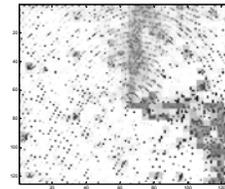
The coherence images are shown in figure 2. The size of the window w is (5×5) . The dominant local orientation is calculated from the gradient and coherence. The dominant local orientation θ is defined as

$$\theta = \frac{1}{2} \tan^{-1} \left(\frac{\sum_{m=1}^M \sum_{n=1}^N \rho_{mn}^2 \sin(2\theta_{mn})}{\sum_{m=1}^M \sum_{n=1}^N \rho_{mn}^2 \cos(2\theta_{mn})} \right) + \pi/2 \quad \text{---(3)}$$

Where, M and N are equal to 8. Thus, each 8×8 window represents one directional information



A: Approximate image B: Horizontal details



C: for vertical details

Figure 2. Coherence images

4. Proposed Algorithm

The proposed algorithm for fingerprint verification consists of

- 4.1. Locate core point and crop fingerprint image around core point.
- 4.2. Discrete wavelet transform
- 4.3 Estimate local dominant orientation using coherence.
- 4.4 Estimate variance and energy of approximate, horizontal, vertical component.

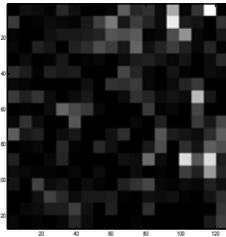
For the fingerprint image alignment, the singular points (Core and Delta) are used. There are number of methods to detect the singular points out of which the popular one is the method based on poincare index. In this algorithm the core point of a fingerprint image has been located based on the basis of maximum curvature property of a curve. Figure 3. shows a typical core point detected fingerprint image



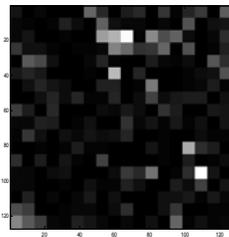
Figure 3. Core point located image

Around the core point the image is cropped in a size 128 by 128 and it is used further for wavelet decomposition. The diagonal component is discarded. Gradient in x and y directions are computed using Sobel gradient operators. The local dominant direction is computed as discussed in Section 4. A block of size 8 by 8 is represented by a local dominant orientation.

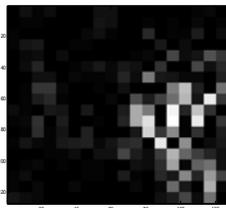
The variance and energy of each block of the approximate, horizontal, vertical images are computed. Variance feature of approximate, horizontal, vertical images are shown in Figure 3.



A: Approximate details



B: Horizontal details



C: Vertical details

Figure 4. Variance field

5. Fingerprint Matching

The fingerprint matching is carried out using three features, local dominant orientation, variance and energy. Correlation matching is used when orientation is a feature

and Euclidean distance matching for variance and energy feature. The trainee and test images are aligned using core point.

$$d = \sum_{u=1}^m \sum_{v=1}^n (V(u, v) - V'(u, v))^2 \quad \text{---- (4)}$$

where,

$V(u, v), V'(u, v)$ are variance feature vectors of trainee and test images respectively

6. Experimental Results and Discussions

We have used two different databases [10] for experimentation. Each database consists of 8 images of each subject and 10 subjects. In total we have used $20 \times 8 = 160$ images overall for experimentation.

The performance of the algorithm is evaluated using FAR and FRR.

Table 1. Verification Results

FRR in Percentage	FAR in Percentage
59.37	0
47.5	0.95
36.87	4.27
15	6

The effect of translation is minimized to some extent as the trainee and test images are align to the core point. The results may improve by using the efficient image alignment method.

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