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Half-orientation extraction of palmprint features ☆

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ABSTRACT

Orientation features of the palmprint are usually used in palmprint recognition methods. Conventional orientation based methods are always based on an assumption that the line in a palmprint is straight and possesses only a single dominant orientation. However, a large number of "lines" in a palmprint are curves. The point in these curves usually has two dominant orientations. Moreover, it can be seen that there are numerous cross wrinkles in a palmprint. The cross point of any two cross wrinkles obviously has two different dominant orientations. In this paper, we proposed a simple and effective double half-orientation based method for feature extraction and recognition of the palmprint. In the method, a bank of "half-Gabor" filters are defined for the half-orientation extraction of a palmprint. Compared with the single dominant orientation, the double half-orientations can more precisely characterize the global orientation feature of a palmprint. Extensive experiments are carried out on three different kinds of palmprint databases and the results show that the proposed method achieves a promising performance in both palmprint verification and identification and outperforms other orientation feature based methods.

1. Introduction

Biometrics, such as personal authentication based on the DNA, face, fingerprint, iris, voice, signature and gait, have been widely studied [1–3]. As a relatively new and novel biometric authentication technology [4,5], palmprint recognition has received more and more attention recently. The palmprint is defined as the inner surface of a palm, which possesses not only fingerprint-like feature such as minutiae points, singular points and texture but also some other special discriminative features such as principal lines, wrinkles and patterns of ridges. As a result, palmprint based recognition has the potential to achieve reliable performance [6–9]. Huang et al. [10] used the principle lines of the palmprints to perform personal verification. Both principal lines and wrinkles were extracted for palmprint authentication in [11].

For people may have similar principal lines, minutiae of the palmprint are also exploited for palmprint identification. For instance, the minutiae of the palmprint were successfully used in matching latent palmprint images for forensic applications [12,13]. Chen et al. [14] designed a palmprint identification algorithm using the hierarchical minutiae of the palmprint. At the same time, increasing research efforts had been directed devoted to the fusion of multiple traits of the palmprint. Dai and Zhou [15] proposed a multi-feature based method, where the principal lines, minutiae points and density map were extracted and fused. Xu et al. [16] designed a fusion method for palmprint identification by combining the left and right palmprints and obtained notable accuracy improvement.

The orientation feature of the palmprint carries very discriminative information. Most of state-of-the-art orientation based coding methods are proposed in recent years. Zhang et al. [17] implemented an online system for palmprint identification. It utilized a normalized 2-D Gabor filter to extract a special orientation feature of palmprint i.e. palmcode and achieved satisfactory performance in a real time application. Since then, different kinds of coding methods were proposed. Kong and Zhang [18] proposed a competitive code method by extracting the dominant orientation of the palmprint, which used six Gabor filters with different orientations to convolve with the palmprint image and the orientation of the filter with maximum filter response is extracted as the dominant orientation. Based on the winner-take-all rule, the robust line orientation code method (RLOC) [19] extracted the principal orientation code of a palmprint using a modified finite radon transform. The fusion code method [20] employed four filters to convolve with a palmprint and binarized the phase of filtering result with the maximum magnitude among four filter responses. Inspired by the competitive code method and sparse representation, Zuo et al. [21] proposed a sparse multiscale competitive code (SMCC) method which used a group of multiscale Gabor filters to extract multiscale orientation features of a palmprint. By comparing filtering results of two orientations, Sun et al. [22]

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employed three incorporated Gaussian filters to extract three bits ordinal codes of a palmprint. Rather than directly encoding the dominant orientation, the binary orientation co-occurrence vector (BOCV) [23] convolved the palmprint image with a set of Gabor filters on six orientations and binarized the signs of all six filter responses. Further, Zhang et al. [6] extended the BOCV namely E-BOCV by filtering out the fragile codes of the BOCV.

In this paper, a simple and efficient half-orientation based coding method is proposed. This work has following contributions. First, a more reasonable orientation representation namely half-orientation representation is exploited. Double half-orientations can better characterize the global orientation feature of a palmprint than the conventional single dominant orientation. Second, a bank of half-Gabor filters are especially defined to extract the double half-orientation codes of a palmprint. Extensive experiments are conducted on three different types of palmprint databases to evaluate the efficiency and effectiveness of the proposed method.

The rest of this paper is organized as follows. Section 2 illustrates the half-orientation of a palmprint. The double half-orientation based method is proposed in Section 3. In Section 4, a series of palmprint recognition experiments are reported. Finally, Section 5 concludes this paper.

2. Double half-orientations of palmprint

The line is the most important and typical feature of a palmprint [4,10]. The extraction algorithm of orientations of lines has been applied for palmprint recognition. By simply coding the orientation feature of a palmprint, a high accuracy of palmprint recognition could be achieved. It is noted that all conventional orientation based methods are based upon an assumption that the lines in the palmprint images are always straight. In other words, only one dominant orientation exists in a "line" of the palmprint. However, in real conditions, it is not hard to see that most lines in a palmprint are curves. Fig. 1 shows an example, from which we can see that the principal lines in a palmprint image are usually curves. The points in these curves usually have two independent and different orientations which are referred to as double half-orientations in this paper. Using the single dominant orientation, as shown in Fig. 1(c), we generally cannot very accurately represent the global orientation feature of the palmprint. In contrast, double half-orientations, which can be extracted by using double half-part-of-filters shown in Fig. 1(d), are more suitable to characterize the global orientation feature of the palmprint. The radian of these curves can be characterized by the combination of both half-orientations. It should be pointed out that the ordinary single dominant orientation is actually a special case of the double half-orientations when both half-orientations are the same.

Carefully observing the palmprint image we can see that there is a number of cross wrinkles in a palmprint, the cross point of which obviously has two dominant orientations that are consistent with these two wrinkles. Fig. 2 shows an example of these kinds of cross wrinkles. As a result, double half-orientations are more precise than the single dominant orientation to represent the orientation feature of these cross points. Based on the above analysis we propose a simple and effective double half-orientation based method for palmprint recognition.

3. Double half-orientation code based method

3.1. Half-Gabor filters

The Gabor filter is one of the most effective tools for orientation extraction of the palmprint. Because it has good properties of the 2-D spectral specificity of textures as well as variation with 2-D spatial position, it is appropriate for feature extraction of the line of the palmprint images [4,17]. In [25], different types of filters, such as Gabor and Gaussian filters, had been compared in orientation feature extraction and the comprehensive experiments demonstrated that the Gabor filter performed better than other filters. In this study, we also apply the Gabor filter to define the half-Gabor filter for extraction of the half-orientation of the palmprint. The real part of the typical circular Gabor filter has the following general form

$$G(x, y, \theta, \mu, \sigma) = \frac{1}{2\pi\sigma^2} \exp\left\{-\frac{x^2+y^2}{2\sigma^2}\right\} \cos\left(2\pi\mu(x\cos\theta + y\sin\theta)\right) \quad (1)$$

where μ is the radial frequency in radians per unit length, θ is the orientation of the Gabor function in radians, and σ is the standard

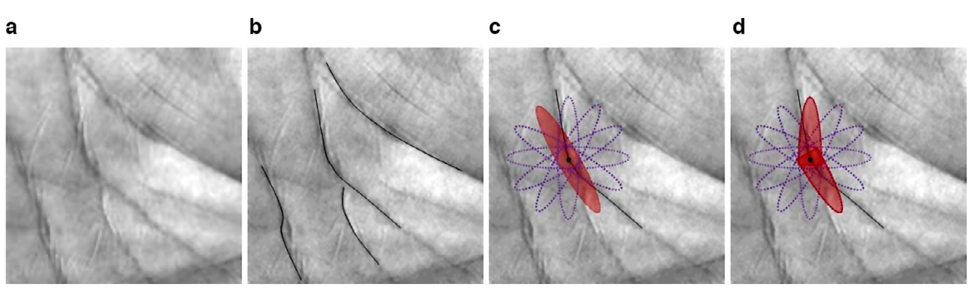

Fig. 1. The line appearance in a palmprint: (a) is an original palmprint image; (b) shows that the principal lines of the palmprint are usually curves; (c) depicts the procedure of the conventional dominant orientation extraction; (d) depicts the procedure of the double half-orientation extraction.

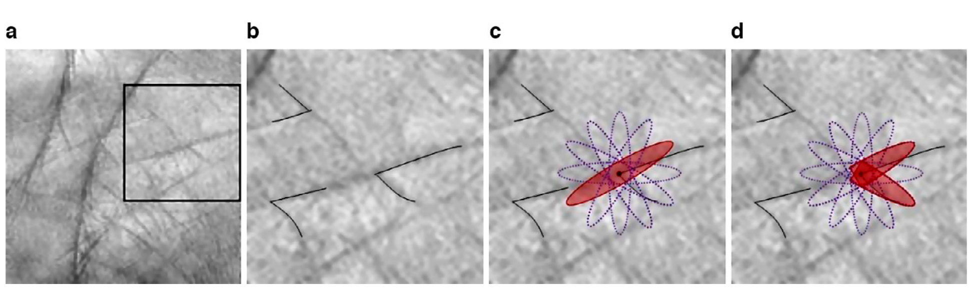

Fig. 2. Cross wrinkles in a palmprint: (a) shows an original palmprint image; (b) shows some cross wrinkles in the palmprint image; (c) depicts the procedure of the conventional dominant orientation extraction; (d) depicts the procedure of the double half-orientation extraction.