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Palm vein recognition method based on fusion of local Gabor histograms

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Abstract

Gabor features have been shown to be effective for palm vein recognition. This paper presents a novel feature representation method, implementing the fusion of local Gabor histograms (FLGH), in order to improve the accuracy of palm vein recognition systems. A new local descriptor called local Gabor principal differences patterns (LGPDP) encodes the Gabor magnitude using the local maximum difference (LMD) operator. The corresponding Gabor phase patterns are encoded by local Gabor exclusive OR (XOR) patterns (LGXP). Fisher's linear discriminant (FLD) method is then implemented to reduce the dimensionality of the feature representation. Low-dimensional Gabor magnitude and phase feature vectors are finally fused to enhance accuracy. Experimental results from Institute of Automation, Chinese Academy of sciences (CASIA) database show that the proposed FLGH method achieves better performance by utilizing score-level fusion. The equal error rate (EER) is 0.08%, which outperforms other conventional palm vein recognition methods (EER range from 2.87% to 0.16%), e.g., the Laplacian palm, minutiae feature, Hessian phase, Eigenvein, local invariant features, mutual foreground local binary patterns (LBP), and multi-sampling feature fusion methods.

Keywords palm vein recognition, Gabor filter, local histogram, Fisher's linear discriminant

1 Introduction

1.1 Related work

Since the development of the Internet and electronic commerce, traditional recognition techniques such as personal identification numbers, magnetic swipe cards, keys, and smart cards are incapable of meeting the demands of security applications because they are easy to observe and cannot provide a high level of security against identity theft. In addition to conventional personal identification methods, biometric information is increasingly being used for personal identification because intrinsic physiological information is harder to observe and can provide a higher level of security. Among various biometric techniques available, palm vein recognition is becoming popular because it provides robust features and can be measured with a low-cost device.

In general, palm vein recognition techniques can be separated into four categories. Firstly, geometry-based methods [1–2] utilize lines, curves, and points to approximate a palm vein pattern. Secondly, statistics-based methods [3–5] such as LBP, local derivative patterns (LDP), and Gabor kernel use statistical information to recognize pattern features. Thirdly, local invariant-based methods [6–8] such as scale-invariant feature transform (SIFT) and RootSIFT (root SIFT) can extract local invariant palm vein features directly rather than employing image processing or feature space transforms. Finally, appearance-based methods [9–11] are the most utilized for feature extraction without prior knowledge.

Of the afore-mentioned classification methods, the statistics-based category has been widely used for numerous biometric identification and verification systems. Among them, the Gabor feature approach is one of the most successful and has been widely used in many biometric application, such as face [12], iris [13] and

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palm-print [14] recognition.

Although Gabor feature-based approaches have been used successfully in biometric identification, the dimensionality of the feature space is very high for the recognition of palm veins. For example, if we select 4 scales and 6 orientations for a Gabor filter convolution group, each with a magnitude and phase response pattern of 256×256 pixels at a 256 gray-scale, then the final spatial feature vector length is $4\times6\times2\times256\times256 = 3\,145\,728$. Such high-dimensional feature vectors dramatically increase the computational runtime and complexity of the feature matching stage. To solve this problem, previous studies [15–16] proposed using a histogram of the Gabor response pattern to represent features.

Feature extraction from a single biometric source is not sufficiently accurate or reliable. In order to improve this, relevant fusion methods [17–19] have been investigated. It is feasible to combine the Gabor magnitude and phase information in order to achieve better accuracy [15].

1.2 Our work

In this paper, we propose a novel palm vein representation referred to as the FLGH method. The basic idea of this approach is that in order to alleviate the sensitivity of a Gabor response to variations in light intensity and slight position changes among different palm vein samples from the same person, the local feature should be determined in a less restrictive way. Meanwhile, to take full advantage of all Gabor magnitude and phase response information, and enhance the discriminative power, we fuse this information into a single representation by coding the LGPDP and LGXP into a uniform feature vector [16].

The key contribution of the proposed FLGH method can be summarized as follows:

Firstly, a novel local feature representation method called LGPDP is proposed. It can represent the palm vein feature derived from the Gabor magnitude response (GMR) effectively. Unlike the existing conventional methods such as [16, 20], the LMD operator is used to establish a maximum difference direction as a binary string sequence. This is an effective method of acquiring palm vein feature of GMR because the original texture of palm vein is relatively less pronounced than in other images such as human face biometric modality.

Second, the LGPDP and LGXP feature is coded into a uniform vector. Then its dimensions are clipped using the proposed spatial partition based (SPB)-FLD method. This method solves the small sample size (SSS) problem and reduces the number of training samples required.

Third, the effectiveness of the proposed method is rigorously evaluated using both the feature-level and score-level fusion scheme and compared to the conventional palm vein recognition method. Experimental results show that our method in score-level mode achieves the EER at 0.08%, which is better than many conventional palm vein recognition methods such as the Laplacian palm [21], minutiae feature [22], Hessian phase [1], Eigenvein [10], local invariant feature [6], mutual foreground LBP [18], and multi-sampling feature fusion methods [17].

The overall procedure for the proposed FLGH palm vein representation method is described as Fig. 1.

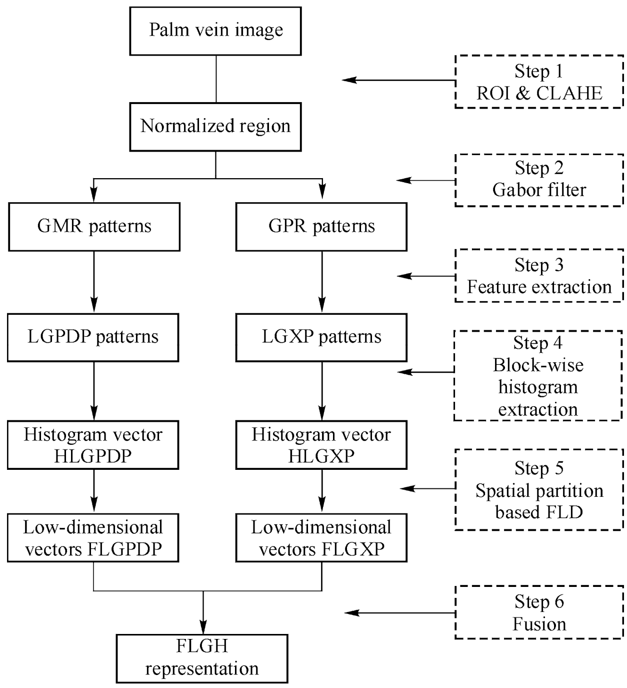

Fig. 1 Framework of the proposed FLGH palm vein representation method

First, we use the proposed LGPDP to encode GMR pattern while using the LGXP to encode Gabor phase response (GPR). Second, to reduce feature dimensionality, we divide all patterns into several non-overlapping regions and calculate the histogram information for all regions. Finally, we use Fisher's SPB linear discriminant method to further reduce feature dimensions.

Step 1 Extract a region of interest (ROI) from the infrared illumination palm vein image provided by the