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An automated palmprint recognition system

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Abstract

Recently, biometric palmprint has received wide attention from researchers. It is well-known for several advantages such as stable line features, low-resolution imaging, low-cost capturing device, and user-friendly. In this paper, an automated scanner-based palmprint recognition system is proposed. The system automatically captures and aligns the palmprint images for further processing. Several linear subspace projection techniques have been tested and compared. In specific, we focus on principal component analysis (PCA), fisher discriminant analysis (FDA) and independent component analysis (ICA). In order to analyze the palmprint images in multi-resolution-multi-frequency representation, wavelet transformation is also adopted. The images are decomposed into different frequency subbands and the best performing subband is selected for further processing. Experimental result shows that application of FDA on wavelet subband is able to yield both FAR and FRR as low as 1.356 and 1.492% using our palmprint database.

Keywords: Biometric; Palmprint recognition; Palmprint pre-processing; Subspace projection methods; Similarity matching

1. Introduction

Recently, a new biometric feature based on palmprint has been introduced. Palmprint recognition refers to the process of determining whether two palmprints are from the same person based on line patterns of the palm. Palmprint is referred to the principal lines, wrinkles and ridges appear on the palm, as showed in Fig. 1. There are three principal lines on a typical palm, named as heart line, head line and life line, respectively. These lines are clear and they hardly change throughout the life of a person. Wrinkles are lines that are thinner than the principal lines and are more irregular. The lines other than principal lines, as well as wrinkles, are known as ridges, and they exist all over the palm.

Palmprint serves as a reliable human identifier because the print patterns are not duplicated in other people, even in monozygotic twins. More importantly, the details of these patterns are permanent. The rich structures of the palmprint offer plenty of useful information for recognition. There are two popular approaches to palmprint recognition. The first approach is based on the palmprint statistical features while the other on structural features. For statistical based palmprint recognition approach, the works that appear in the literature include eigenpalm [1], fisherpalms [2], Gabor filters [3], Fourier Transform [4], and local texture energy [5].

Another important feature extraction approach is to extract structural information, like principal lines and creases, from the palm for recognition. Funada et al. [6] devised a minutiae extraction method for palmprints. This idea was inspired by the fact that palmprint also contains minutiae like fingerprints. Zhang and Shu [7] determined the datum points derived from the principal lines using the directional projection algorithm. These datum points were location and rotational invariant due to the stability of the principal lines. Unlike the work proposed by [7], Duta et al. [8] did not explicitly extract palm lines, but used only isolated points that lie along palm lines as they deduced that feature point connectivity was not essential for the matching purposes. As opposed to the work by [6], Chen et al. [4] recognized palmprint by using creases. Their work was motivated by the finding that some crease patterns are related to some diseases of people. Another structural based method used by Wu et al. [10] was to implement fuzzy

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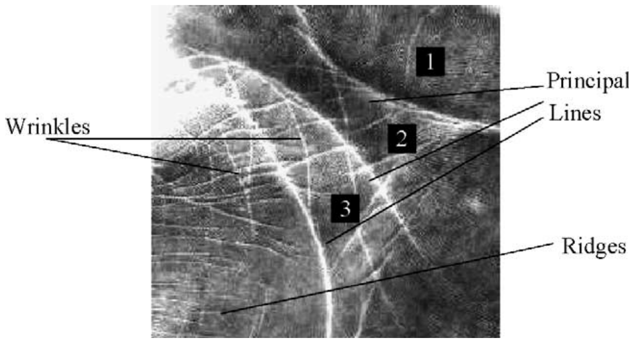

Fig. 1. The line patterns on the palmprint. The three principal lines on a typical palm: 1-heart line, 2-head line and 3-life line.

directional element energy feature (FEDDF) which originated from the idea of a Chinese character recognition method called directional element feature (DEF). On the other hand, Han et al. [11] performed Sobel's and morphological operations to extract palmprint structural features from the region of interest (ROI).

In the first statistical features based palmprint recognition approach, the palmprint image is treated as a whole for extraction, representation and comparison. Thus, the recognition process is straightforward. However, as abundant textural details are ignored, the natural and structural information of the palmprint cannot be characterized. On the other hand, structural approach can represent the palmprint structural features clearly. Besides, image with lower quality can be used for structural approach as lines can be detected under low-resolution. However, this method is restricted by the complication in determining the primitives and placements of the line structures, and usually more computational power is required to match the line segments with the templates stored in the database. Each approach demonstrates its strengths and weaknesses, and the choice depends on the temperament of application: operational mode, processing speed, memory storage and quality of the image acquired.

In addition to the feature selection process, image capturing method is another important factor to be evaluated. The palmprint recognition methods proposed by [4–10] utilized inked palmprint images. These approaches are able to provide high-resolution images and are suitable for methods which require fine resolution images to extract lines, datum points and minutiae features. However, these methods are not suitable for online security systems as two steps are required to be performed: ink the palmprint images on papers and then scan them to obtain digital images. Some recent works demonstrated by [3,10,12] used CCD based digital camera to capture palmprint images. The digital images acquired could be directly fed into computer for computation. Another approach proposed by [11] used scanner as the acquiring device. The advantage of scanner is that it is equipped with a flat glass that enables the users to flatten their palm properly on the glass to reduce bended ridges and wrinkle errors. Some authors like [4,10] fixed some guidance pegs on the sensor's platform to limit the palm's shift and rotation. Some users will feel uncomfortable when their hands images are acquired. In addition, this approach requires additional peg-removal algorithm to remove the pegs from the hand image. Works introduced by [12] do not use fixed pegs to increase flexibility and user-friendliness of the system.

In this paper, an automated peg-free scanner-based palmprint recognition system is proposed. Two novel components are contained in the proposed system. First, a pre-processing module that automatically aligns palmprint images from peg-free sensor is developed. This module segments hand image from the background and extracts the center region of the palm for recognition. Second, systematic comparison and analysis of three types of subspace projection techniques, namely principal component analysis, fisher discriminant analysis and independent component analysis, using a standard palmprint database is presented. In order to analyze palmprint images in multi-resolution-multi-frequency representation, the wavelet transformation is also adopted.

In the next section, the overview of the proposed palmprint recognition system is provided and each of the system's components is discussed in details. Section 3 presents the experiment setup, as well as the results of this research. In Section 4, we make some concluding remarks. Finally, the review of PCA, FDA, ICA and Wavelet Transform theories are provided in Appendix A for the convenience of readers unfamiliar with these techniques.

2. Overview of system architecture

The proposed system is divided into two phases, namely the enrollment and verification phase, as shown in Fig. 2.

The important tasks contain in the system include the pre-processing, feature extraction as well as feature matching. In the pre-processing stage, the alignment and orientation of the hand images are corrected for use in the successive tasks. In the feature extraction stage, the most discriminating features from the palms are extracted for representation, and finally in the feature matching stage comparison is performed and decision is made whether two palmprint features are from the same person. The details of each of these components are discussed in the subsequent sections.

2.1. Pre-processing

In this system, no guidance pegs are fixed on the scanner's platform and the users are allowed to place their hands freely on the platform of the scanner when scanned. Thus, palmprint images with different sizes, shifts and rotations are produced. Therefore, a pre-processing algorithm has been developed to correct the orientation of the images and also convert the palmprints into same size