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Consistency analysis on orientation features for fast and accurate palmprint identification

Feng Yue [a,*], Wangmeng Zuo [b]

[a] Beijing Institute of New Technology Applications, Beijing, China
[b] School of Computer Science and Technology, Harbin Institute of Technology, Harbin, China

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ABSTRACT

A typical palmprint identification system identifies a query palmprint by matching it with the templates in the database and comparing the similarity score with a pre-defined threshold. However, continual database expansion would make conventional brute force search method inefficient for large-scale palmprint identification. In this paper, we propose a consistent orientation pattern (COP) hashing method to enforce fast search. Using the orientation and response features extracted by steerable filter, we first give an analysis on the consistency of orientation features, and then introduce a method to construct COP using the consistent features. Because the COP is very stable across the samples of the same subject, the COP hashing method can find the target template quickly and thus can lead to early termination of the searching process. Experiments have been carried out on several real and synthetic databases, and the results show that the COP hashing method can accelerate the identification process by more than an order of magnitude, and can achieve comparable identification accuracy while compared with the state-of-the-art approaches.

1. Introduction

Palmprint recognition, a relatively novel but promising biometric technology, has received considerable research interests in the last decades [31,18,8,25]. After more than ten years' algorithm and system development, a number of palmprint recognition based biometric systems have been successfully applied for real world access control applications [23].

A palmprint identification system typically involves a number of templates of registered subjects and a pre-defined similarity threshold. When a query comes, the brute force search based system usually matches the query with the templates one by one until it finds the target template whose similarity score is higher than the threshold [10]. One query may be correctly identified, or wrongly identified as other subject, or "no match" is found if all the similarity scores are lower than the threshold.

By far, a number of palmprint recognition approaches have been proposed in the literature. Among them coding-based methods [16,22,17,14] are the most promising ones because of their small feature size, fast matching speed, and high accuracy. In the feature extraction stage, these methods encode the responses of a bank of filters into bitwise code, and in the matching stage, the similarity score can be efficiently computed by Boolean operators.

Despite the fast matching speed of coding-based methods, when applied on a large-scale identification system, it is often necessary to speed up the searching process. Although several strategies have been proposed for fast palmprint identification [24,26,29], these methods, however, either lead to much accuracy loss or only obtain limited speedups.

* Corresponding author. Address: Pattern Recognition Research Center, Beijing Institute of New Technology Applications, Beijing Academy of Science and Technology, Beijing, China. Tel.: +86 10 58937360; fax: +86 10 58957958.
E-mail addresses: csfyue@gmail.com (F. Yue), cswmzuo@gmail.com (W. Zuo).

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In this paper, we propose a consistent orientation pattern (COP) hashing method for fast and accurate palmprint identification. We first extract orientation features using steerable filter, and then select more consistent ones based on consistency analysis. COPs are then constructed based on the consistent features and are used as the indexes to the target template. Because of the stability of the COP across the samples of the same subject, the proposed COP hashing method can quickly find the target template, leading to early termination of the searching process. Compared with the state-of-the-art approaches, the proposed method can achieve comparable identification accuracy and substantial improvement in search speed.

The remainder of this paper is organized as follows. Section 2 reviews some related work. Section 3 presents the orientation feature extraction method using steerable filter. Section 4 introduces the consistency analysis on orientation features. Section 5 describes the COP construction and hashing methods. Section 6 presents the experimental results and the discussions, and Section 7 gives our conclusion.

2. Related work

In this section, we provide a brief review on the related work. A comprehensive and updated survey on palmprint recognition algorithms can be found in Ref. [32].

2.1. Consistency analysis on features

In the field of biometrics, feature consistency is usually used to denote the stability of features across the samples of the same subject. Previous studies indicate that not all the features are equally important, and the inconsistent features are assumed to be less significant for biometric recognition. In iris recognition [20,4], Daugman [5] first proposed a "mask" in an iriscode to label the bits occluded by eyelids and eyelashes as the inconsistent bits. Daugman claimed that these bits are not stable and should be ignored in the matching stage. Bolle et al. [1] further assumed that the rest bits in an iriscode are not equally consistent. Later Hollingsworth et al. [11] conducted an experimental analysis on real iris database to show that some bits are more consistent than others. They investigated the causes of inconsistency using *single* sample and pointed out that the main reason is the coarse quantization of the phase response. By masking out the inconsistent bits when matching of iriscodes, improvement in recognition accuracy can be obtained based either on iris individuality model or on real iris databases. Moreover, instead of simply splitting the bits into consistent and inconsistent ones and representing them using binary variables, Dong et al. [6] proposed to quantify the bit consistency to integers of 0–255. The class-specific feature consistency can be learned from *multiple* training samples of the same subject, and thus is named as personalized weight map (PWM). Experimental results showed that PWM could significantly improve the accuracy of an iris recognition system. Despite the effectiveness of this technique, a number of training samples (typically 10 or more) per subject are required for learning the weight map.

Orientation feature has been demonstrated to be one of the most promising features for palmprint recognition [32]. In the literature, gradient-based and filter-bank based approaches are two popular approaches for orientation feature extraction [34]. Compared with gradient-based approach, the filter-bank based approach is more robust against noise, and thus has been widely employed to extract orientation features for palmprint recognition [16,14,35]. However, when only a small number of filters are used, the extracted orientation feature would be coarse. In order to deal with this problem, Zuo et al. [36] proposed a steerable filter based approach for accurate orientation feature extraction and a generalized angular distance (GAD) measure for effective matching of accurate orientations. The GAD has the properties of tolerance for small angular difference and penalty for large angular distance, and thus is more robust against quantization errors.

2.2. Fast identification

Biometric identification system identifies the person by comparing the query with the templates in the database. One simple way to accomplish this task is to perform brute force exhaustive search in the database. When applied on a large-scale identification system, it is often necessary to speed up the searching process. Early fast identification approaches can be roughly classified into two categories, hierarchical matching and classification. Hierarchical matching [27,26,19] typically involves extracting multiple kinds of features and then searching in a layered fashion. Simpler features which can be quickly extracted and matched are used in higher layers to allow a large number of candidates to be discarded. Classification strategies [24,33] divide palmprints into several classes and match the query only with the templates in its class. However, both strategies speed up the searching process at the expense of accuracy.

Recently, Yue et al. [29] proposed a fast palmprint identification strategy based on competitive code and the cover tree method. Compared with brute force search, this approach can obtain identical identification results, and is 33–50% faster. In [30], they improved the method in [29] by optimizing the tree structure. The experimental results show that the approach can further speed up the searching process without any accuracy loss, and the speedup can be further enhanced by including more templates per subject in the database. While both methods can reduce the identification time without accuracy loss, the speedups over brute force search are somewhat limited. Besides, these methods are not applicable for the identification systems where only one template per subject is stored in the database.