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Interdigital palm region for biometric identification

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ABSTRACT

The interdigital palm region represents about 30% of the palm area and is inherently acquired during palmprint imaging, nevertheless it has not yet attracted any noticeable attention in biometrics research. This paper investigates the ridge pattern characteristics of the interdigital palm region for its usage in biometric identification. An anatomical study of the interdigital area is initially carried out, leading to the establishment of five categories according to the distribution of the singularities and three regions of interest for biometrics. With the identified regions, our study analyzes the matching performance of the interdigital palm biometrics and its combination with the conventional palmprint matching approaches and presents comparative experimental results using four competing feature extraction methods. This study has been carried out with two publicly available databases. The first one consists of 2,080 images of 416 subjects acquired with a touchless low-cost imaging device focused on acquiring the interdigital palm area. The second database is the publicly available BiosecurID hand database which consists of 3,200 images from 400 users. The experimental results presented in this paper suggest that features from the interdigital palm region can be used to achieve competitive performances as well as offer significant improvements for conventional palmprint recognition.

1. Introduction

THE interdigital region is the area of the palm between the base line of the fingers and the transverse creases (distal and proximal ones) [1,2]. At the fetal stage, the skin in that area is stressed in different directions to allow the formation of the fingerwebs and the beginning of the fingers. It yields an area rich in random, unique and stable structures for each individual.

These structures, creases, wrinkles, minutiae and singularities can be found all around the hand palm. Creases and wrinkles or palm lines have been extensively studied by the biometric research community for personal identification. They can be conveniently acquired with low cost devices based on CCD/CMOS sensors that are able to provide low-resolution images around 150 dpi. As these structures are concentrated around the palm center, it is common to extract an invariant area around the palm center that contains the most prominent creases on the palm: the radial longitudinal transverse crease, the distal transverse crease and the proximal transverse crease as well as several secondary lines [3,4]. The availability of several free public databases may be one of the reasons why most research and commercial schemes are based on these palm creases. As seen in Fig. 1, the use of central area is common as the region of interest, however it misses the interdigital region which is reasonable due to the relative lack of creases and wrinkles in this area.

Singular points, orientations and minutiae on the hand palm provide higher discriminative ability [3,5–7] and require a resolution over 300 dpi. Usual devices to acquire high resolution palm images are AFIS/APIS devices (e.g. Safran Morpho and Pappilon). Disadvantage of these acquisition devices are the missing palm regions of the acquired image due to the optical properties of the system and the anatomic characteristics of the palm. As can be seen at Fig. 1, the upper interdigital area is missed in these images because of the curvature of the metacarpal bones. Nevertheless, these devices are mainly used by forensic experts because of the accuracy of these structures for personal identification while scarcely being used by the biometric community due to the difficulties in obtaining automatically a reliable and stable singularities pattern because of the wrinkles and creases.

Problems with the automatic acquisition of a stable ridge-line pattern in the hand are moderate in the interdigital area because of the previously mentioned lack of creases and wrinkles. Unfortunately part of this area is lost in the high resolution images, see Fig. 1. Nevertheless we think a study of the features of this area should be added

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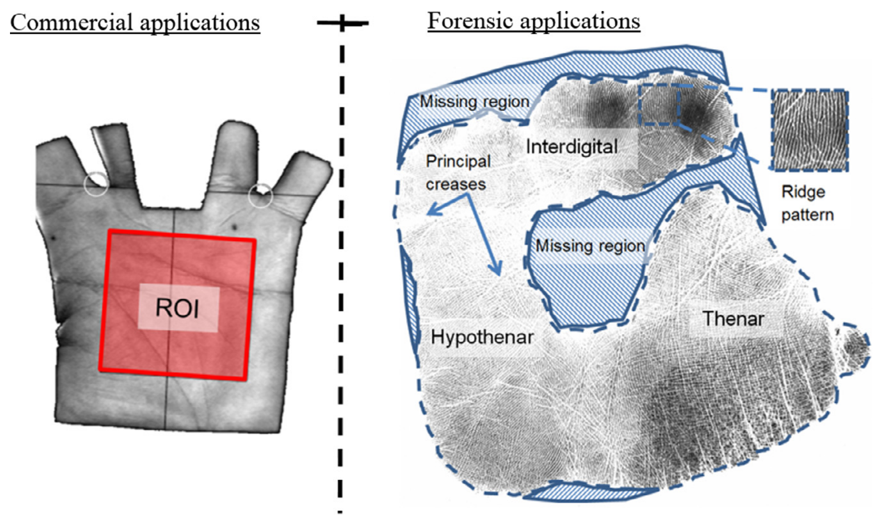

Fig. 1. On the left: traditional palmprint recognition image and ROI used in commercial applications [3][3]; on the right: high resolution palmprint images acquired with APIS devices.

to actual palm based biometric devices because it could mean a step forward in performance of these biometric devices.

In this paper we propose the use of the interdigital area for biometric person recognition. As it contains a complex structure of singular points and ridge orientations, an exhaustive analysis of the interdigital area has been carried out.

The key contributions from this paper can be summarized as follows:

(i) This paper investigates and develops an anatomic taxonomy on the interdigital palm region ridge patterns for the biometrics applications. Our investigation suggests that the distribution of the singularities in the interdigital region can be used to classify palms from different subjects into a few classes (Section 3.1). We infer a model of the singularities distribution (Section 3.2) which leads to selection of effective regions of interest, based on the spatial distribution of the singularities in the interdigital area, that can maximize its performance for personal identification (Section 3.3).

(ii) After adapting the most relevant features to the interdigital area (Section 4), this work presents a study of the discriminative ability of the interdigital area (Section 5.1) and its complementarity with the commonly employed central palm for the personal authentication (Section 5.2). Our experimental evaluation is carried out using four competing feature extraction methods and two publicly available databases that comprises more than 800 users. The experimental results demonstrate the comparative discriminative ability of the interdigital region and its effectiveness in improving (up to 50% of improvement in EER) the performance of the conventional palmprint recognition. This work does not propose the interdigital area as an alternative to replace traditional palmprint approaches but as a complement to improve already existing ones.

This study required a database acquired with device that can acquire the interdigital area with a resolution that allows ridge singularities to be detected. This device was developed by us and used to acquire a database of palm images without skin distortion from 416 subjects. Furthermore, the database developed and employed in this study is made publicly available for further research in forensics and civilian biometric applications at www.gpds.ulpgc.es.

The rest of the paper is organized as follows: Section 2 describes the self-built acquisition device and the databases used; Section 3 deals with the taxonomy of the interdigital region based on its ridge pattern; feature extraction methods and experiments are reported in Sections 4 and 5, respectively. Finally Section 6 draws some conclusions where the interdigital trait results are compared with the state of the art of high and low resolution palm biometrics.

2. Acquisition device and databases

2.1. Acquisition device

The device to acquire the interdigital region to study the ridge-pattern is made with a webcam (Logitech C600) and a compact fluorescent lamp (CFL) inside a case. The light incident from one side increases the contrast between creases and ridges for greater visibility. The case contains an opening hole of 8 ×4 cm to capture the whole interdigital region and three guiding pegs ensure the correct positioning of the hand during recognition/identification.

When the user places the hand over the guiding pegs, his/her interdigital region lies above the opening of the case and its image can be acquired without skin deformation, see Fig. 2.

The webcam used contains $N \times M = 1600 \times 1200$ pixels. Its sensor size and focal length are $L \times P = 0.4536 \times 0.3416$ cm and $f = 0.44$ cm ,respectively. Therefore, its horizontal and vertical angle of view are $\alpha_h = 2 \cdot \text{atan}(L/2f) = 54.53^\circ$ and $\alpha_v = 2 \cdot \text{atan}(P/2f) = 42.43^\circ$, respectively. The webcam was located $h = 8$ cm below the vertical of the open hole, so it covers an area of $2 \cdot h \cdot \tan(\alpha_h/2) \times 2 \cdot h \cdot \tan(\alpha_v/2) = 8.2 \times 6.2$ cm which is slightly greater than the opening. In this case the resolution obtained is 468 dpi in the horizontal direction and 464 dpi in the vertical direction. The proposed low cost device captures the whole interdigital area (the region from the transverse creases to the base of the fingers) and allows the singularities and ridge orientations to be studied.

2.2. GPDSInterd Database

The database acquired with the described device is made up of 2580 images from 416 people. The age of the subjects ranges from 15 to 94 with 234 males and 182 females. The first 100 users were acquired in two sessions separated one month while the remaining 316 users provided images in only one session. Each of the sessions contains 5 images. The guiding pegs help to reduce the within class rotation and translation variability during the acquisition while ensuring the visibility of the region under the ring, middle and index fingers for all users. The quality of acquired images mainly varies due to external factors such as nature of work (manual laborers and office workers) practiced by subjects. Each user was manually classified