A Rotational- and Translational-Invariant Palmprint Recognition System

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Abstract. *Computer-aided personal recognition is becoming increasingly important in our information society. Biometric identification is an emerging technology that can solve security problems in our networked society. As the important implementation of biometric technology, palmprint verification is one of the most reliable personal identification methods. Human palmprint recognition has become an active area of research over the last decade. In this paper, a new approach to the palmprint preprocessing phase is presented. In real-time palmprint verification the input subject to the scanner for image acquisition may suffer rotational as well as translational variation. Because while the user puts his/her palm on the scanner, the angle and position of the palm may change. So, different images are acquired by the scanner according to the input each time. But in our paper we have suggested a rotational- as well as translational-invariant scheme by which the above problem can be overcome while preprocessing the image before the feature extraction of the palmprint. With several palmprint images, we tested our proposed preprocessing system and the experimental results found good.*

Keywords: *Biometric, Palmprint, Security, Human Recognition, Feature Extraction.*

1. Introduction

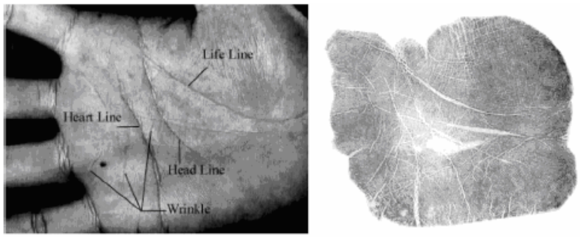
With the development of more and more systems which provide service based on the identity of a person the importance of personal identification is growing. Providing authorized users with secure access to the service is a challenge to the personal identification systems. There are several conventional means for personal identification which include passports, keys, tokens, access cards, personal identification number (PIN), passwords. Unfortunately, passports, keys, tokens, access cards, can be lost, stolen or duplicated, and passwords, PINs can be forgotten, cracked or shared. These drawbacks cause a great loss to the concerned. A reliable solution is required fill the loopholes of the conventional personal identification methods. Biometric systems are proving to be an efficient solution to this problem. These systems are based on the human traits which, unlike conventional methods, cannot be lost, stolen or duplicated. The first commercial system, called *Identimat*, which measured the shape of the hand and the length of fingers, was developed in the 1970s. At the same time, fingerprint-based automatic checking systems were widely used in law enforcement. Because of the rapid development of hardware, including computation speed and capture devices, iris, retina, face, voice, signature and DNA have joined the biometric family. Fingerprint identification has drawn considerable attention over the last 25 years. However, some people do not have clear fingerprints because of their physical work or problematic skin. Iris and retina recognition provide very high accuracy but suffer from high costs of input devices or intrusion into users. Recently, many researchers have focused on face and voice verification systems; nevertheless, their performance is still far from satisfactory. The accuracy and uniqueness of 3-D hand geometry are still open questions.

The remaining sections are organized as follows: Brief outline of palmprint recognition systems is presented in section 2. Palmprint image preprocessing steps are mentioned in Section 3. The other phases of the palmprint recognition like feature extraction, template storage and matching of palmprint images are briefly explained in section 4. Experimental results are given in Section 5. Finally, Section 6 describes the concluding remarks.

2. Palmprint Recognition Systems

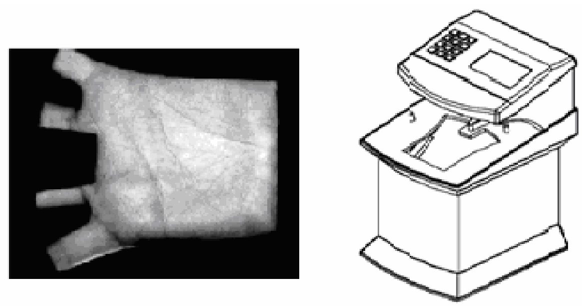
A few years ago, a new branch of biometric technology, palmprint authentication, was proposed whereby lines and points are extracted from palms for personal identification. In this work, we consider the palmprint as a piece of texture and apply texture-based feature extraction techniques to palmprint authentication [5]. Compared with the other physical characteristics, palmprint authentication has several advantages: (1) low-resolution imaging; (2) low intrusiveness; (3) stable line features and (4) high user acceptance. Palmprint authentication can be divided into two categories, *on-line* and *off-line*. Fig. 1(a) and (b) show an on-line palmprint image and an off-line palmprint image, respectively.

Research on off-line palmprint authentication has been the main focus in the past few years [1], where all palmprint samples are inked on paper, then transmitted into a computer through a digital scanner. Due to the relative high-resolution off-line palmprint images (up to 500 dpi), some techniques applied to fingerprint images could be useful for off-line palmprint



(a) (b)

Fig. 1. Examples of (a) on-line and (b) off-line palmprint images.



(a) (b)

Fig. 2. (a) on-line palmprint image obtained by a palmprint scanner and (b) a palmprint scanner.

authentication, where lines, datum points and singular points can be extracted [1]. For on-line palmprint authentication, the samples are directly obtained by a palmprint scanner. Fig. 2(a) shows a palmprint image captured by a palmprint scanner and Fig. 2(b) shows the outlook of a palmprint Scanner. Note that a low-resolution technique (75 dpi) is adopted to reduce the image size, which is comparable with fingerprint images even though a palm is much larger than a fingerprint.

It is obvious that on-line identification is more important for many real-time applications, so that it draws our attention to investigate. Generally, on-line palmprint verification system contains five modules, palmprint acquisition, preprocessing, feature extraction, matching and storage. The five modules are described below:

- ***Palmprint Acquisition***: A palmprint image is captured by a palmprint scanner and then the AC signal is converted into a digital signal, which is transmitted to a computer for further processing.
- ***Palmprint Preprocessing***: A coordinate system is set up on basis of the boundaries of fingers so as to extract a central part of a palmprint for feature extraction.
- ***Textured Feature Extraction***: Some filter or transforms like Gabor filters, Fourier Transforms, or Wavelet Transforms can be applied to extract textural information from the central part of the palmprint image.
- ***Matching***: Some distance measure like Euclidean or Nearest Neighbor Distance measures can be used to match the similarity of two palmprints.
- ***Database***: It is used to store the templates obtained from the enrollment phase.

The samples first passed through preprocessing and feature extraction to produce the templates stored in a given database. The whole process is simulated by taking the palmprint images from PolyU Palmprint database. In this paper, we focused on the preprocessing of the image. The rest of the phases can be any of the schemes mentioned before.

3. Palmprint Preprocessing Scheme

In this project work we have not taken any palmprint scanner for acquisition of palmprint images. Rather we have used the online database of palmprints (PolyU Palmprint Database: http://www.comp.polyu.edu.Hk/~biometrics/). Before feature extraction, it is necessary to obtain a sub-image from the captured palmprint image and to eliminate the variations caused by rotation and translation. The five main steps of palmprint image preprocessing are as follows (see Fig. 3):

Step 1: Applying a low-pass filter to the original image. Then by using a threshold T_p, this original image is converted into a binary image as shown in Fig. 3(b). Mathematically, this transformation can be represented as

$$B(x,y)=\begin{cases}1, & \text{if} \quad O(x,y)*L(x,y)\geq T_p\\ 0, & \text{if} \quad O(x,y)*L(x,y)<T_p\end{cases} \quad \dots (1)$$

where $B(x,y)$ and $O(x,y)$ are the binary and the original images, respectively; $L(x,y)$ can be any lowpass filter, such as Gaussian, and "*" represents the operator of convolution.

Step 2: Extracting the boundaries of the holes, $(B_i x_j, B_i y_j)(i=1,2)$, between fingers using our boundary-tracking algorithm. The start points (Sx_i, Sy_i) and end points (Ex_i, Ey_i) of the holes are then marked in the process (see Fig. 3(c)).

Step 3: Computing the center of gravity (Cx_i, Cy_i) of each hole with the following equation:

$$Cx_i=\frac{\sum_{j=1}^{M(i)} B_i x_j}{M(i)}, \quad Cy_i=\frac{\sum_{j=1}^{M(i)} B_i y_j}{M(i)} \qquad \dots (2)$$

where $M(i)$ represents the number of boundary points in the hole, i. Then constructed a line that passes through (Cx_i, Cy_i) and the midpoint (Mx_i, My_i) of (Sx_i, Sy_i) and (Ex_i, Ey_i). The line equation is defined as

$$y = x\left(\frac{My_i - Cy_i}{Mx_i - Cx_i}\right) + \left(\frac{My_i Cx_i - Mx_i Cy_i}{Mx_i - Cx_i}\right) \qquad \ldots (3)$$

Based on these lines, two key points, (K_1, K_2), can easily be detected (see Fig. 3(d)).

Step 4: Line up K_1 and K_2 to get the Y-axis of the palmprint coordinate system and make a line through their mid point which is perpendicular to the Y-axis, to determine the origin of the coordinate system (see Fig. 3(e)). This coordinate system can align different palmprint images.

Step 5: Extracting a sub-image with the fixed size on the basis of coordinate system, which is located at the certain part of the palmprint for feature extraction (see Fig. 3(f)).

4. Other Phases of Palmprint Recognition

The other phases after preprocessing are briefly explained one by one as follows.

4.1. Palmprint template storage

After the preprocessing of the image, the generated central parts of the palmprint images are stored in a database. Then these templates are used for feature extraction and matching.

4.2. Filtering and feature extraction

Generally, principal lines and wrinkles can be observed from our captured palmprint images (see Fig. 1(a)). Some edge detection algorithms can obtain the principal lines. However, these lines do not contribute adequately to high accuracy because of their similarity amongst different palms. Fig. 4 shows six palmprint images with similar principal lines. Thus, wrinkles play an important role in palmprint authentication but accurately extracting them is still a difficult task. So texture analysis can be applied for palmprint authentication. Fourier transforms [2], derivative of Gaussian filters [7], Gabor filters [5], and wavelet transforms [3, 6] can be used for feature extraction.

4.3. Palmprint matching

For matching two palmprint images, different distance measures are taken such as Euclidean distance [6], Hamming distance [5], nearest neighbor distance (NND) rule [6].

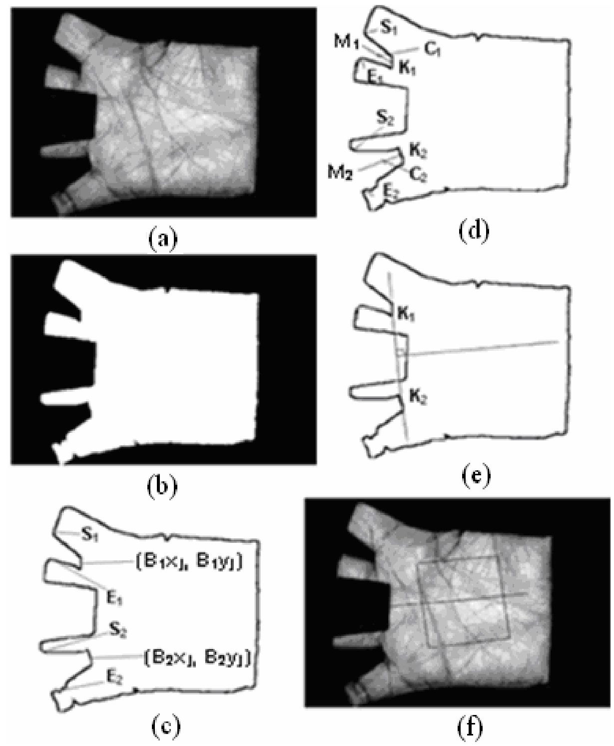


Fig. 3. Main steps of preprocessing: (a) original image, (b) binary image, (c) boundary tracking, (d) key points (K_1, K_2) detecting, (e) the coordinate system and (f) The central part of a palmprint.

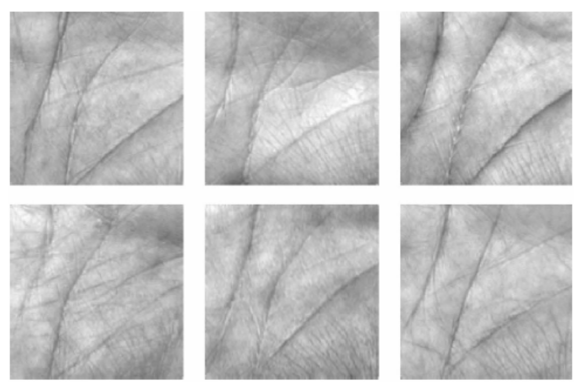


Fig. 4. Six images with similar principal lines.

5. Experimental Results

In the following experiments, palmprint images are collected from the PolyU palmprint database. Fig. 5 shows some of the palmprint images from PolyU database. To simulate our rotational- as well as translational-invariant image preprocessing scheme we have manually rotated the palmprint images to different angles around 1 to 10 degrees both clockwise and counterclockwise. Then we preprocessed the various images and our generated central parts are found similar for all the rotated images of the same original palmprint.

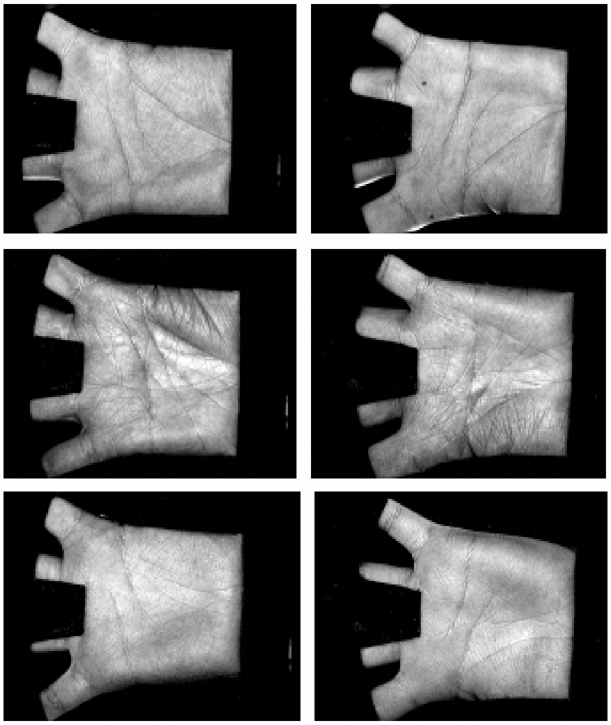


Fig. 5. Palmprint images from PolyU Database

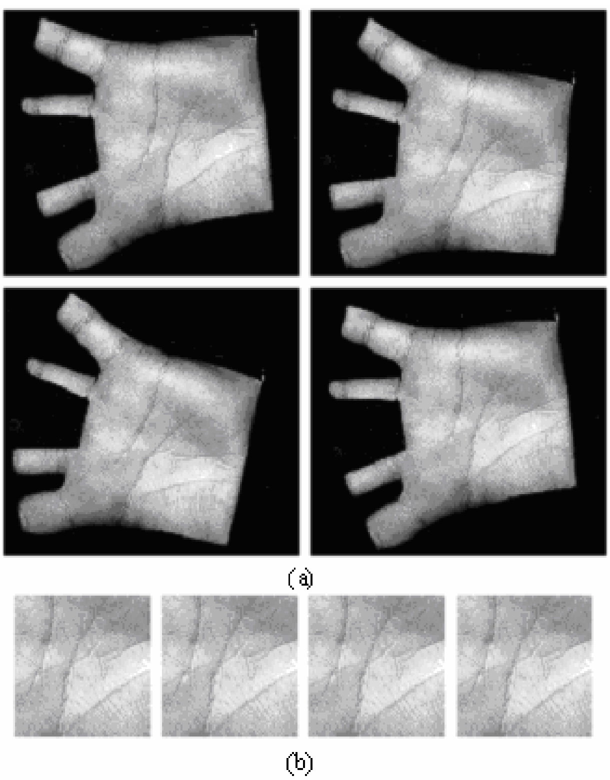


Fig. 6. (a) Rotated input palmprint images for preprocessing and (b) output generated central parts of the image

Fig. 6 shows the rotated input images and output generated central parts of the image which are similar. As we have considered the centre of gravity of the two holes of the palmprint image, if the image is rotated, still the centre of gravity of the hole remains same. Also the new coordinate system is based on that centre of gravity of the hole; so also, if the image is translated a small distance the result is same.

6. Conclusion

This paper presents a rotational- and translational-invariant scheme of palmprint image preprocessing, which generates low-resolution palmprint images for personal authentication. As the preprocessed images are low-resolution images, the computational complexity of feature extraction methods decreases. Combined with the effects of preprocessing and rotated preprocessed images, our matching process is also translation and rotational invariance. Experimental results illustrate the effectiveness of the method.

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