Developing a Method for Segmenting Palmprint into Region-Of-Interest

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Abstract: A considerable number of papers have been published in the last decade about biometric recognition using palm-print features. One of the most important stages in these methods is pre-processing which contains some operations such as filtering, Region Of Interest (ROI) extraction, normalization, etc. This paper proposes a precise method for extracting ROI of the palm-print. The basis of this method is geometrical calculations and Euclidean distance. Although pre-processing has been discussed in different papers incidentally, but no definite precise approach has been introduced. We show that our approach will extract the ROI with the accuracy of 99.7%.

Keywords: ROI, Euclidean distance, Centric point, Palm-print.

INTRODUCTION

Today a wide variety of applications require reliable verification schemes to confirm the identity of an individual, recognizing humans based on their body characteristics and these techniques have become more and more interesting in emerging technology applications. Biometric can not be borrowed, stolen, or forgotten, and forging one is practically impossible [1]. Among different body characteristics, palm-print has attracted scientists in the last decade and many papers have been presented based on it [2, 3]. There are some reasons which have caused palm-print recognition find popularity. The most important factors are: 1) Low complexity; 2) High accuracy; 3) Low-resolution imaging; 4) Stable line features; 5) High user acceptance; [4].

Biometric recognition based on palm-print features contains different processing stages such as data acquisition, pre-processing, feature extraction and matching. This paper focuses on the pre-processing section which is quite important in providing high accuracy in pattern recognition. Among those papers which have discussed about palm-print recognition, seldom any of them discussed about pre-processing in detail. So, we pay more attention to this part and its most important stage which is extracting the ROI. This region that is the basis of pattern recognition in next processes (feature extraction and matching) is shown in Fig. 1(b).

Generally there are two kinds of images used in palm-print recognition: Online and Offline. Online images are those taken with digital cameras or scanners. Offline ones are those produced by ink on paper [5]. The database we use for testing our method is PolyU [6] that uses online images. The images in this database are low-resolution ones and are suitable for real-time application testing. A sample of the images in the discussed DB is shown in Fig. 1(a).

In the following sections, we mention some prior work about the case in section 2. Section 3 provides the details of our proposed method. Section 4 discusses the experimental results including noise test. Section 5 concludes the major findings of this paper.

1. Prior work

Most of the methods used to extract a region on palm for personal authentication use geometrical techniques [3, 7]. Nevertheless a paper which has extracted ROI using spectral approach is Han et al [8]. They have used wavelet-based segmentation to find the locations of finger tips and four finger roots. For attaining this, they have found boundary of palm image and then have transformed palm boundary’s coordinates to a profile of curvature. Then they used wavelet transform to convert the curvature into a multi-resolution signal (which included low- and high-frequency sub-bands). At last, they separated these sub-bands and detected corner points of palm’s
boundary through local minimums of transformed profile (its high frequency sub-band). Although this method shows successful in extracting ROI precisely, it suffers from high demands of processing and therefore it is not appropriate for real-time applications. On the other hand, geometrical techniques used in other researches can not promise high accuracy in extracting ROI and most of them state that their approach is an approximate (not absolute) solution [7].

A noticeable method which uses geometrical techniques in extracting ROI is discussed in [4]. It enjoys computing the center of gravity of holes located between fingers and by this, they extract ROI of the palm image. The main goal of our paper is to improve the accuracy of ROI extraction through this method and introduce new techniques to eliminate the variations caused by rotation and translation.

2. Methodology

The first step in pattern recognition is pre-processing. The images in the database we use, suffer from noise, shadows and severe changes in illumination. So at the beginning, we exert median filter on the images. This filter has a smoothing effect and its significant vantage is that it does not make images opaque. This operation is necessary especially for noise test which we will perform on our method at experimental results section.

After filtering images, we should find a way to distinguish palm images from the background. A common way to achieve this is to detect boundary of palm in the image. To detect the palm’s boundary, at first, we should convert the image to a binary image. To do this we use histogram analysis used in [7]. As shown in Fig. 2(a), histogram of a grayscale palm image is bimodal [10]. It means that by detecting a local minimum (Q point) in the histogram and using it as our threshold, we can convert the palm image into a binary image. Equation (1) shows the decision process to make the binary image ( \( f(x, y) \) is the palm image function).

\[
f(x, y) = \begin{cases} 
255 & \text{if} \quad f(x, y) \geq \text{Gray level}_0 \\
0 & \text{if} \quad f(x, y) < \text{Gray level}_0
\end{cases}
\]  

(1)

The palm image’s histogram and the binary image we have attained by this technique are shown in Fig. 2.

The next step to segment the palm image into ROI is to trace the boundary of the binary image. Here we use an algorithm called inner boundary tracing (8-connectivity type) discussed in [10]. The result of this algorithm which is exerted on binary image of the palm is shown in Fig. 3(a).

![Fig. 2. (a) Histogram of a palm image with a local minimum (Q point); (b) Binary image attained by histogram analysis technique.](image)

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Fig. 3. (a) Boundary image attained by exerting inner boundary tracing algorithm on (a sample) binary palm image. (b) Showing two important points in ROI generation: \( P_0 \) and Centric point of the palm binary image.

The last stage in our approach is ROI generation. The information we have up to now is the boundary of palm as sequential coordinates in the image. Now, we show that using this boundary pixels and centric point of boundary image (Fig. 3(b)), we can generate ROI.

Centric point of the palm boundary image which is our reference in finding ROI is calculated by the equations (2, 3) and is shown in Fig. 3(b). Here \( f(i, j) \) is our palm image function and \([X_{\text{centroid}}, Y_{\text{centroid}}]\) is the coordinates of the centric point.

\[
m_m = \sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} i^2 j^2 f(i, j)
\]

(2)

\[
\begin{align*}
X_{\text{centroid}} &= \frac{m_0}{m_m} \\
Y_{\text{centroid}} &= \frac{m_1}{m_m}
\end{align*}
\]

(3)

Another reference point is on the palm’s boundary and is found by searching in binary image from the left and down corner of the image. This point (\( P_0 \)) which is the first pixel found on the palm’s boundary is shown in Fig. 3(b).
Then, we start from point \( P_0 \) and go round the palm’s boundary (one turn). Meanwhile, we calculate the Euclidean distance between each pixel \((x, y)\) on the boundary and the centric point as equation (4).

\[
D(x, y) = \sqrt{(x - x_{centroid})^2 + (y - y_{centroid})^2}
\]  

(4)

The diagram of Euclidean distances is shown in Fig. 4(a). There are some key points (i.e. extremum) on this diagram that some of them help us generate ROI. These points are shown in Fig. 4(b).

![Diagram of Euclidean distance from point \( P_0 \) to the boundary](image)

**Fig. 4.** (a) Diagram of Euclidean distance of boundary pixels from centric point; (b) Key points detected on the palm boundary image

Using these key points, we find points A, B, C, D that are the initial and end points of the holes between fingers in the boundary image. These points are shown in Fig. 5(a). A sample of the way we find these points is shown in Fig. 5(a, b). In these figures it is seen that using point 6, we find \( H_1 \) and then calculate Euclidean distance of pixels on the boundary (point 6 to point 4) from \( H_1 \). Through the diagram which we attain (Fig. 5(b)), point B could be found as shown. If we continue in this way, we can recognize other points (A, C, D) as following (Look at Fig. 6). Using point 4, we find centric point \( H_2 \). Then we find point D similar to Fig. 5(a). At last using point \( P_0 \) we find centric point \( H_4 \). Then we find point C similar to Fig. 5(a).

![Diagram of Euclidean distance from point \( P_0 \) to the boundary](image)

**Fig. 5.** (a) Centric point for detecting point B; (b) Diagram of Euclidean distance from point \( H_1 \) and the point on the diagram which is relevant to point B.

Continuance of the approach to generate ROI is shown in Fig. 7 which has been discussed in detail in [4] and we review it briefly. At first, we find the mid point of straight AB line and centric point of AB hole as equations (2, 3). Then we line up these two points to reach point \( N_y \) (on the palm’s boundary in Fig. 7(a)). We do the same process to reach \( N_x \). After that we line up these two points and line up from the midpoint of \( N_y \) perpendicular to it. The length of this line is one third of \( N_y N_x \)’s. Through these operations we find \( K_y \) (the first point on ROI). Using this point and the slope of \( N_y N_x \), the 128*128 pixel square (ROI) is generated.

**3. Experimental results**

Despite most of the approaches used to segment palm image [3, 4, 7], the proposed method does not force users to put their hand between pegs or in defined direction. The database we use is PolyU [6]. It includes 600 palm images of 100 different individuals.
The ROI images we attained from each palm image had fixed size of 128*128 pixels (Fig. 7(b)) which is a standard in palm images’ pre-processing [3, 11].

To evaluate the performance of the proposed method, we performed tests on original and artificially noise-polluted palm images and compared it with the method used in [7]. Different types of noises we chose to exert on palm images were Salt & Pepper noise with various densities and Gaussian noise with zero average and different variances. Result of the test is presented in Table 1. We define the accurate ROI extraction as if the length of each of principal lines (definition of principal lines and other lines in palm image is given in [9]) in the extracted ROI contains at least 70% of the original relevant principal line’s length in the palm image [12].

4. Conclusion

This paper develops a method for segmenting palm images into a region which is proper for palmprint recognition (called ROI). This method uses some algorithms like histogram analysis and inner boundary tracing to detect palm in an image and then performs some geometrical operations to generate ROI. One of the advantages of the proposed method is that it is not sensitive to rotation and translation. Results are promising, with accuracy as high as 99.7% for original palm images and averagely about 92% for highly noise-polluted ones.

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5. Acknowledgements

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REFERENCES


