A New Palmprint Segmentation Method
Based on an Inscribed Circle

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Abstract – Palmprint segmentation, which involves extracting a suitable part of a palmprint for feature extraction and matching, provides the basis for palmprint identification. In this paper, we propose using an inscribed circle for palmprint segmentation. The proposed method is able to obtain the contour of a palmprint and calculate the biggest inscribed circle for the contour. The part of the palmprint that falls within the circle is extracted for further processing. In comparison to the earlier proposal of a segmentation method that uses a square, the new method can deal with more distortions in the original images, provides a higher accuracy and includes more meaningful features. Experimental results demonstrate the effectiveness of using the inscribed circle for segmentation.

Index Terms – Palmprint identification, image segmentation, inscribed circle, preprocessing.

1 INTRODUCTION

Computer-based personal identification, also known as biometrics computing, has been widely investigated in recent years [1-9]. Fingerprint identification has been regarded as the most effective method for many security systems. Although it is an equally accessible part of the hand and larger in size and richer in creases and wrinkles, the palmprint has not been investigated intensively for personal identification purposes yet. Until now, only a few studies have been reported on palmprint identification. Zhang et al. introduced their inked palmprint identification method [10], where two key points in a palmprint are defined and decided automatically by combining projection and line tracing methods, and a pattern-based line-extraction method is used to obtain the line pattern on a palmprint. However, their work is solely on inked palmprint identification using high-resolution images, and it can not tackle the problems of on-line palmprint identification using lower resolution images. In an earlier paper [11], we proposed a
Fourier Transform feature extraction and matching method for on-line palmprint images. Also, we introduced a palmprint segmentation method based on a square and preprocessing of the original images. However, the segmentation method used in [11] has two major limitations: 1) Require a captured image with a relatively high quality and impose extra constraints on the subjects when the image is obtained; and 2) Take a relative small extracted area of a palmprint and some useful features are lost. In this paper, our aim is to extract a larger part of a palmprint, which includes more meaningful personal features and imposes fewer constraints on users.

Palmprints may exhibit some degree of distortion (rotation, shift, transform, etc.) due to their being captured at different times, and under varying conditions of temperature, humidity, brightness, etc. To compare two palmprints, a common coordinate system is needed to determine which part of a palmprint is going to match with a similar part in another palmprint. Here, we define palmprint segmentation as the process of correcting distortions and putting all palmprints under the same coordinate system so that the expected area of each palmprint can be extracted. So, three key issues are involved in palmprint segmentation. 1) How to define the coordinate system? 2) How to decide the key points of the defined coordinate system on each palmprint image? 3) How to define and extract the useful part of a palmprint? When a suitable segmentation method is defined, several criteria are used in evaluating it. 1) How correctly is the defined area extracted? 2) How large is the segmented area? 3) How many effective features are included in the segmented area? 4) How much time does the method take? 5) How much tolerance does the method have in dealing with various distortions in an original image?

In this paper, we propose using an inscribed circle for palmprint segmentation. The main idea of the proposed method is to first obtain the contour of a palmprint and then calculate the biggest inscribed circle for the contour. The part of the palmprint that falls within the circle is extracted.
as a useful area for further processing. In comparison with using a square for segmentation, the new method is more accurate, retains more features, and is tolerant to more distortions in the original images. Fig. 1 shows some palmprints that were captured by our capturing device.

The rest of this paper is organized as follows. In Section 2, we present the use of a square in the segmentation method, which is partially introduced in [11]. Our proposed segmentation method that is based on using an inscribed circle is introduced in Section 3. In Section 4, comparisons and experimental results are given.

2 SQUARE-BASED SEGMENTATION METHOD

Segmentation is aimed at automatically and precisely extracting the central part of a palmprint for feature extraction and matching. A square-based segmentation method is introduced in [11]. The main idea is to first define three key points on a palmprint. An orthogonal coordinate system is then given by using the three points. During segmentation, a square with a fixed size is extracted from a predefined position under the coordinate system. The size and position of the square are determined by using statistics from many palmprints. The basic rule in determining the size and position of the square is to ensure that the part of the image that is extracted is available in all palmprints. The following steps summarize the square-based segmentation approach in detail in order to easily compare with the proposed method in this paper [11].

Step 1. Define the three key points and an orthogonal coordinate system on a palm

We define three key points on a palm, namely K1, K2, and K3 (see Fig. 2). K1 is the midpoint between the index finger and middle finger. K2 is the midpoint between the middle finger and the ring finger and K3 is the midpoint between the ring finger and the small finger. We line up K1 and K3 to get the Y-axis of the palmprint coordinate system. We then take a line through K2.
perpendicular to the Y-axis, to determine the origin of the palmprint coordinate system (see Fig. 2).

**Step 2: Determine its key points and coordinate system for each palmprint image**

Here, we suppose that the fingers are not stuck together and at least four fingers (index, middle, ring and small finger) are present in an image. Therefore, the three gaps between the fingers are obtained, and the three key points are found.

**Step 3: Extract a fixed size sub-image from a fixed position under the coordinate system**

Once the coordinate system is decided, the central part of a palmprint is extracted with a fixed size. In Fig. 2, the square “ABCD” is the area that is extracted. The position of “A” in the coordinate system and the size of “ABCD” are fixed in all palmprints, and these are predefined according to many observations and experiments. Once the central part is extracted, a rotation of the image is performed; therefore, a square rather than a diamond-shaped image is obtained.

A limitation of the square-based segmentation method is that when the three holes between the fingers are not determined precisely, the whole method fails. The image is then regarded as a bad sample and it has to be thrown away, despite the fact that the palm area might be clear enough for identification.

**3 Inscribed-Circle-Based Segmentation Method**

In contrast to the square-based segmentation method, the method based on an inscribed extracts the central part of a palmprint using a circle; therefore a round image is obtained rather than a square. Fig. 3 shows the square and circle on the same palm. The basic idea of using an inscribed circle is to calculate the inscribed circle that meets the boundary of a palm so that it can extract as large an area as possible from the central part of the palmprint (see Fig. 4). The following...
steps describe the details of this method:

**Step 1: Determining the palmprint’s boundary.**

Determining the boundary is a rather simple step. First, we convert the gray image into a binary image using the following formula:

\[
I_{\text{binary}}(i,j) = \begin{cases} 
255 & \text{if } I_{\text{grey}}(i,j) \leq \text{Threshold}, \\
0 & \text{if } I_{\text{grey}}(i,j) > \text{Threshold},
\end{cases}
\]

where \(I_{\text{binary}}(i,j)\) is any point on the binary map, \(I_{\text{grey}}(i,j)\) is the point on the original gray map. And the ‘Threshold’ is the certain number we use to discriminate palmprint area and the background. After turning the map into binary map, we smooth the boundary between the white and black pixels and obtain the contour of a palmprint.

**Step 2: Calculation of the inscribed circle.**

We calculate the biggest inscribed circle for the contour of the palmprint and obtain its center and radius. Because different palms have different sizes, the radiuses may be different. Samples of the same palm have circles with similar radiuses and centers. When matching two palmpints, we first check the radiuses. If the radiuses are not close to each other, we can conclude immediately that the two palmpints are from different palms. Otherwise, further matching is needed within the circle. We suppose that the centers of two palmpints are close but not necessarily exactly at the same point on a palm. Therefore, the matching needs to shift and rotate one of the palmpints to make the match.

**Step 3: Extraction of the central part.**

Once the circle is determined, the extraction only involves obtaining all pixels inside the circle. Fig. 5 shows several successfully segmented palmpints.
4 **A COMPARISON OF THE SQUARE AND INSCRIBED CIRCLE METHODS**

Palmprint segmentation is used to find the useful part of an image. Three criteria are used in evaluating a segmentation method. 1) How precisely it extracts the required part? 2) Can the algorithm deal with more distortions in an image? 3) Does the extracted part include more useful features? In comparing the segmentation that results from using a square or an inscribed circle, we used the three following experiments.

4.1 **Accuracy Test**

**A. Definition**

Generally, there are three main creases on a palm [10]. Here, we define two key points on a palm according to where two of the creases flow out of the palm – A and B in Fig. 6 respectively. In Fig. 6, we also define the center of the square as O1 and the center of the circle as O2. The distance between O1 and A is denoted as \(D_{\text{square-a}}\), and the distance between O1 and B is \(D_{\text{square-b}}\). The distance between O2 and A is \(D_{\text{circle-a}}\), and distance between O2 and B is \(D_{\text{circle-b}}\).

**B. Design of the Experiment**

We obtained 400 palmprints, which are from 80 palms, and manually decided the two key points (A, B) of all palms. Then automatically calculate \(D_{\text{square-a}}, \ D_{\text{square-b}}, \ D_{\text{circle-a}}, \ \text{and} \ D_{\text{circle-b}}\). We then generated the experimental results and compared the two methods.

**C. Experimental results**

Each palm has five palmprint samples, and it is expected that the extracted parts from each sample include the same area of the palm. So, we calculate the average distance between the
centers of five squares and circles to decide which one moves by the least amount. Our experiment shows that both the shifts of $D_{square-a}$ and $D_{square-b}$ are 6 pixels, and the shifts of $D_{circle-a}$ and $D_{circle-b}$ are 5 pixels, respectively. Therefore, we can conclude that the circle-based method is a little more precise than the square-based method.

4.2 Tolerance to Palmprint Images of Different Quality

In some cases, an image cannot be segmented correctly by using the square but it can be processed by the inscribed circle. In our database, there are about 6,000 palmprint images. Only 2/3 of them can be correctly segmented by the square-based method, but all of them can be segmented correctly by the circle-based method. Fig. 7(a) shows a sample in which the index finger has a ring. Fig. 7(d) is a case that the holes between the fingers cannot be identified correctly due to the ring. In Fig. 7(b), the fifth finger cannot be segmented correctly. Fig. 7(c) is a sample that cannot be segmented due to an inappropriate pose of the hand—the gap between the middle finger and the ring finger is too narrow. Fig. 7(g–i) are the segmented parts from Fig. 7(a–c), respectively.

4.3 Comparison of the Sub-image Sizes

Segmentation involves extracting the central part of a palmprint for feature extraction and matching. Therefore, when the size of the extracted sub-image becomes larger, more features are included and it is better for feature extraction. The square is of size $128 \times 128 = 16,384$ pixels (i.e., one side of the square is 128 pixels). The size of the circle varies from palm to palm. The average size of all circles is $100 \times 100 \times 3.14 = 31,400$ pixels (i.e., the average radius of the inscribed circles is 100 pixels).

Samples from the same palm may get different circle sizes, but the difference is usually
within 2-3 pixels and it can be overcome by shift and rotate to be matching map. Since different palms may have larger difference with their circle sizes, in this case, we use the circle size as first-step classification criteria. If two palmprint samples are too far with circle size, a conclusion that they are from different palms is got immediately. Only when two palmprints have similar circle size, their comparison can be done in order to decide whether they are from the same palm.

5 CONCLUSIONS

Palmprint identification is a new method for authentication of identity. Three key issues are involved in palmprint identification: segmentation, feature extraction and feature matching. In this paper we present our novel method for palmprint segmentation, which is based on an inscribed circle in a palm. Compared to the square-based segmentation method proposed in [11], an inscribed circle is more accurate, retains a larger sized palmprint, and it includes more useful features for identification. The experimental results show the effectiveness of the proposed method.

ACKNOWLEDGEMENTS

This work is partially supported by the UGC/CRC fund from the Hong Kong Government, the central fund from the Hong Kong Polytechnic University, the Nation Nature Science Foundation of China [9] #60203001 and the open project of the National Key Lab of the Automatic Institute.

REFERENCES


**Figures**

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