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Comparative Study of ROI Extraction of Palmprint

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Abstract - The Palmprint region segmentation is an important step in Palmprint recognition problem. A comparative study of two segmentation algorithm namely Square-based ROI detection method and Circle-based ROI detection Method are studied and implemented. Firstly, the Square-based ROI detection method uses the Binarization of Palmprint and extract the Boundary, after this detecting key points and establishing a coordination system with extracting the central part as a fixed size square. The circle based ROI detection method uses a 2D rectangular coordinate system with the y-axis formed by the line connecting k1 and k2 and the x-axis is the perpendicular line originating from the midpoint of k1 and k2. And the largest inscribed circle is extracted by searching the centre of line joining k1 - k2 and line perpendicular to it, using four directions. Palmprint region segmentation is realized based on these two methods. The experiment results show that the algorithm is accurate and effective.

Keywords - *Palmprint ROI Detection, Square Based Method, Circle Based Method.*

1. Introduction

In the implementation of Palmprint recognition system, preprocessing is a necessary and crucial step also the effect of pretreatment will directly impact the results of feature extraction and recognition. Its location, orientation, rotation angle and degree of stretch will differ according to the varying degrees of effect, which will affect the feature extraction of the Palmprint.

The purpose of doing preprocessing is to extract from the palm suitable reference points, to establish the spatial coordinates, to reduce the affects of nonlinear factors such as rotation, translation and distortion in sampling process and to improve the match recognition algorithm robustness.

The rest of the paper is arranged as section 2 describes the Square-based Method, section 3 describes the circle based method of ROI detection and section 4 provides the results of experimentation, and at last concluding remarks are given.

2. Square-based Method[1]

Major The square-based segmentation approach is based on defining unique key points on a Palmprint. An orthogonal coordinate system is then given by using these key 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, with rich Palmprint features. The preprocessing is used to segment the centre for feature extraction and set up a coordinate system.

The main purpose of performing preprocessing is to gain a proper sub-area or region of interest (ROI) for the feature extraction and matching. Preprocessing consists of five main steps, 1.Binarization of image, 2.Boundary extraction, 3.Detecting key points, 4.Establishing a coordination system and 5.Extracting the central part. The block diagram of preprocessing is shown in figure 1. below.

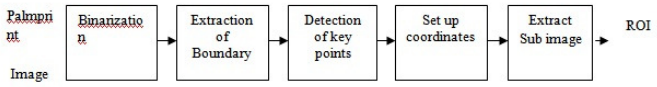

Fig.1 Block daigram of preprocessing for palmprint image

Before starting preprocessing the low pass filter such as Gaussian is applied to the original image so as to smooth the image and to remove high frequency components. As the filter is applied to the palm image, the image is now noise free and can be used for the further preprocessing. The first step of image preprocessing is to binarize the image.

To binarize the image the Otsu's image thresholding method is used.

2.1 Image Binarization

S The threshold (T_p) is found out from the histogram of image that will be local minima as shown in Figure 3(b). This threshold T_p is used to convert the original image into a binary image as shown in Figure 3(c). Mathematically, this transformation can be represented as,

$$B(x, y) = 1 \quad \text{if } O(x, y)*L(x, y) \geq Tp \qquad (1)$$

$$B(x, y) = 0 \quad \text{if } O(x, y)*L(x, y) < T_p \qquad (2)$$

Where B(x, y) and O(x; y) are the binary image and the original image respectively, L(x, y) is a low-pass filter such as Gaussian and "*" represents an operator of convolution. To calculate the proper threshold value T_p the otsu's method is used.

Otsu Method:

Because of the simplicity of computing, higher adaptive strength, the Otsu method has become the most widely adaptive threshold selection method. The algorithm assumes that the image to be thresholded contains two classes of pixels or bi-modal histogram (e.g. foreground and background) then calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal. The method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that fall either in foreground or background. The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum. In brief we exhaustively search for the threshold that minimizes the intra-class variance, which is same as maximizing inter-class variance, defined as a weighted sum of variances of the two classes. The intra-class variance is given by,

$$\sigma_w^2(t) = \omega_1(t)\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t) \qquad (3)$$

Weights ω_i are the probabilities of the two classes separated by a threshold t and $\sigma^2 i$ variances of these classes. As mentioned above minimizing the intra-class variance is the same as maximizing inter-class variance. The inter-class variance is given by,

$$\sigma_b^2(t) = \sigma^2 - \sigma_w^2(t) = \omega_1(t)\omega_2(t)[\mu_1(t) - \mu_2(t)]^2 \qquad (4)$$

The class probability $\omega 1(t)$ and class mean $\mu_1(t)$ is computed from the histogram as t:

$$\omega_1(t) = \sum_{i=0}^{t} p(i) \quad \mu_1(t) = \sum_{i=0}^{t} p(i)x(i) \qquad (5)$$

where x(i) is the value at the center of the ith histogram bin. The class probabilities and class means can be computed iteratively.

Algorithm-

- Compute histogram and probabilities of each intensity level
- Set up initial $\omega_i(0)$ and $\mu_i(0)$
- Step through all possible thresholds t=1 upto maximum intensity
- Update ω_i and μ_i
- Compute $\sigma^2 b(t)$
- Desired threshold T_p corresponds to the maximum $\sigma^2 b(t)$

Using above equations (1) and (2) the calculated T_p binarize the image.

2.2 Boundary Extraction

After thresholding, the binary image is eroded with 3x3 ones structure element to remove irrelevant small objects from the binary image. Later using Sobel edge operator a one bit thick boundary of the Palmprint image is extracted shown in Figure 3(d). To get the boundary pixels the image is scanned row-wise. Using these boundary pixels the reference point P_1 which is the first left-down white pixel of binary image and P_2 is first left-up white pixel of the binary image. This is shown in Figure 3(c).

2.3. Detecting Key Point

Further to calculate key points we trace the boundary pixels from the reference point P_1 Figure 3(c) in clockwise direction and from the reference point P_2 Figure 3(c) in counterclockwise direction. Then the graph between number of boundary pixels which are traced in clockwise direction starting from first reference point P_1 and distance between boundaries point and extreme points of image is plotted as shown in Figure 3(e). K_1 is the first local maxima of graph. Similarly for P2 another local maxima K_2 is calculated from the graph. This local maxima point K_1 is the gap point between little and ring finger and K_2 is the gap between index and middle finger as shown in Figure 3(f).

2.4. Establish a Coordinate System

Draw a line between K_1 and K_2, and find its midpoint K_m. Draw a line from K_m (of 100 pixels) orthogonal to K_1-K_2. Then, draw a rectangle of size 128x128 pixels parallel to the K_1K_2 as shown in Figure 3 (g). The image found in the rectangle is the region of the interest (ROI) for the given Palmprint Figure 3(g). The central part extracted can be

square shaped or circular shaped. The square region is easier for handling translation variation.

3. Circle-based Method[2]

Square based method fails to capture the maximum amount of feature as they always leave out portions of the Palmprint containing important features such as delta points, creases. 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. In order to achieve more information of Palmprint, the maximum inscribed circle should be located inside palm region. In circle-base method, the input Palmprint image is normalized firstly for rotation. It uses a 2D rectangular coordinate system with the y-axis formed by the line connecting k1 and k2 and the x-axis is the perpendicular line originating from the midpoint of K_1 and K_2. For the ease of processing, the Palmprint image is rotated slightly using K as the pivot point such that the line between K_1 and K_2 is now vertical and the y-axis is a horizontal line. In this way further processing is performed on a rotation-corrected image. Once the input image has been normalized for rotation, the largest inscribed circle is extracted by searching the centre of it using four directions. The centre of the largest possible circle is obtained. The following steps as shown in figure 2 are included in the circle-based method.

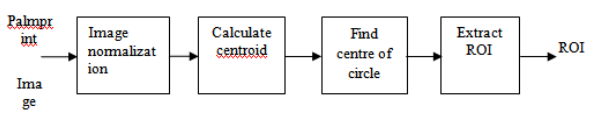

Fig. 2 Block diagram for circle-based method

3.1 Image Normalization for Rotation

In circle-based method image is normalized for rotation. Using the rectangular coordinate system formed due to key points k1 and k2 the image is rotated. An angle of rotation is decided by the pivot of k. The key points k1 and k2 are rotated such a that they become vertical forming vertical y-axis. The angle of rotation is given by the θ = sin-1((k2_x-k2'_x) / r), where r is the distance between k1 and k2 before rotation. Through this angle θ the image is rotated.

3.2. Calculate Centroid

Further we calculate the centric point of the palmprint image as shown in Figure 4(c). Suppose the coordinates of centric points be(x_c,y_c) and it is calculated by following

$$m_{pq} = \sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} i^p j^q f(i,j)$$

$$x_c = \frac{m_{10}}{m_{00}} \qquad y_c = \frac{m_{01}}{m_{00}} \qquad (6)$$

f(i,j) is binary image.

3.3. Find Centre Of The Circle

The largest inscribed circle is extracted by searching the centre of it using four directions. The centre of the largest possible circle is obtained as shown in figure 4(d) and figure 4(e).

3.4. Extract the ROI

Once the centre we get, by choosing proper radius the circle is drawn using following equation.

$$X = X_c + r * \sin d(\alpha) \qquad (7)$$

$$Y = Y_c + r * \cos d(\alpha) \qquad (8)$$

Where r is radius of the circle and (X_c, Y_c) is the centre of the circle, α varies from 0o to 360o.

The circle is drawn with maximum radius.

4. Experimental Results

The Square-based Method and Circle-based Method are implemented to extract the ROI of Palmprint images. The database used for the Palmprint images is PolyU Palmprint database from Hong Kong University. The experimental results are as shown below in figure 3 and Figure. 4.

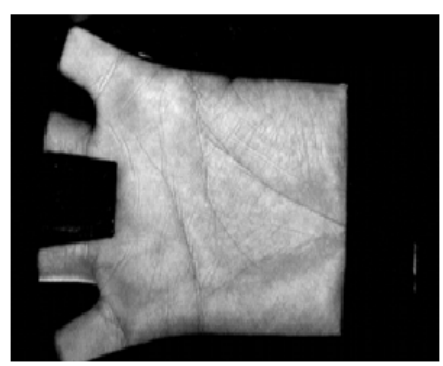

Fig. 3(a) Original image

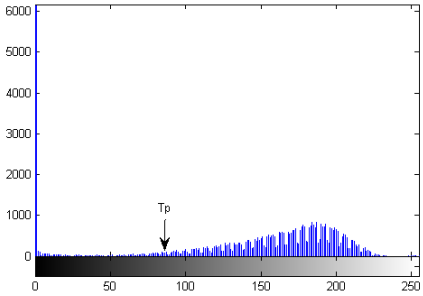

Fig. 3(b) Histogram of image with threshold Tp

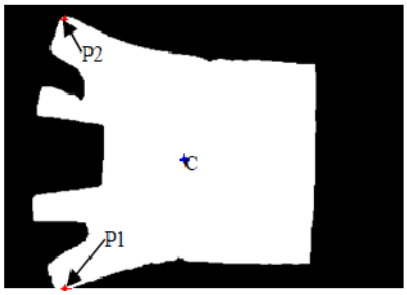

Fig.3(c) Binary image with centroid C and Reference point P1 and P2

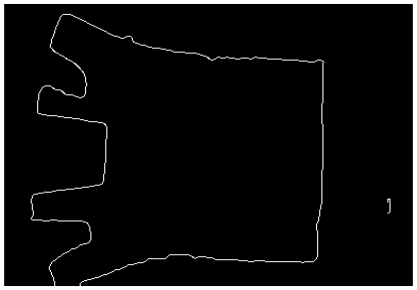

Fig.3(d) boundary Palmprint image

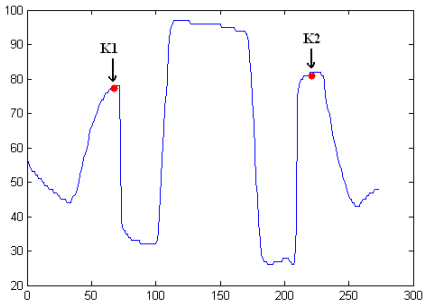

Fig. 3(e) Graph plotted to calculate K1 and K2

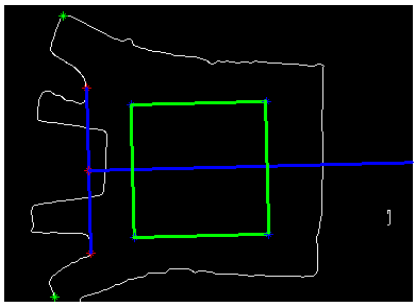

Fig. 3(f) Established coordinate system with ROI

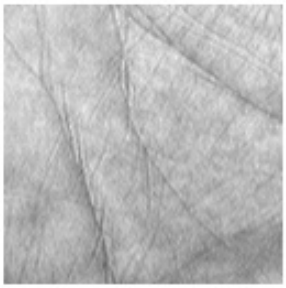

Fig. 3(g) Palmprint with ROI

Fig.4(a) Binary image before rotation

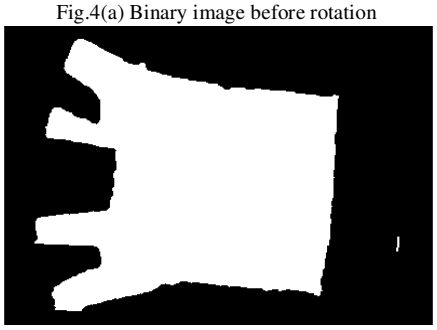

Fig. 4(b) Binary image after rotation

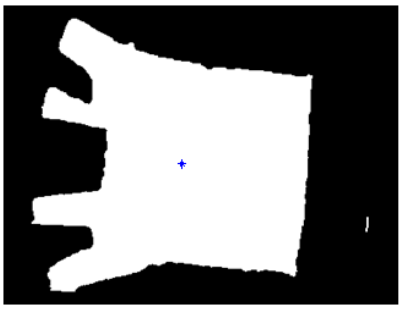

Fig. 4 (c) Centroid of rotated binary image

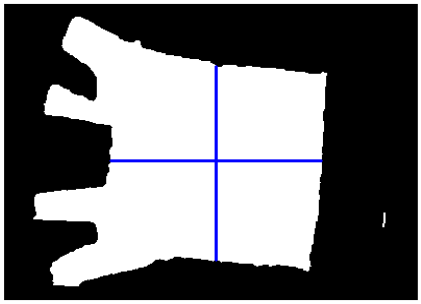

Fig. 4(d) Centre of the circle

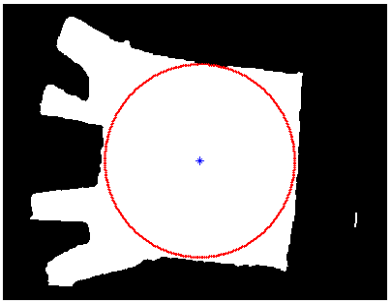

Fig. 4(e) Palmprint with inscribed circle drawn

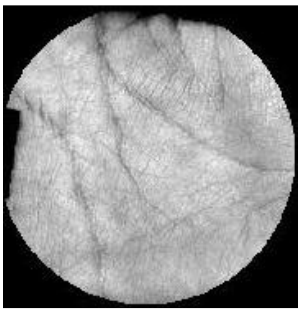

Fig.4(f) Palmprint with ROI

4. Conclusions

The Palmprint segmentation algorithms are studied, the segmentation based on Square-based ROI detection method and Circle-based ROI detection Method are implemented.

The simulation results show that Palmprint segmentation results are better, and gives the area of valid Palmprint i.e. Region of Interest which have important features for Palmprint recognition. These two methods the overcome the shortcomings caused by palm rotation and translation. The circle based method gives the larger area under ROI as compared to Square-based method which gives more information in circle based method. But the radius of circle based method is not fixed so different area is captured during ROI detection where as in square based method the fixed size area is extracted. Also the interference caused due to the boundary region is more in circle based method compared to square based method.

References

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