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Segmentation of Palmprint into Region of Interest (ROI): A Survey

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Abstract: Palmprint is one of the most reliable physiological characteristics that can be used to distinguish between individuals. Palmprint recognition process consists of image acquisition, pre-processing, feature extraction, matching and result. 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. This paper provides a survey on various different methods to segmentation of palmprint into ROI and extraction of principle lines. ROI segmentation of palmprint is to automatically and reliably segment a small region from the captured palmprintimage.We pay more attention towards more essential stage of palm localization, segmentation and ROI extraction. Finally some conclusion and suggestion is offered.

Keywords: Biometrics, Palmprint, ROI, Region based segmentation, Image pre-processing, principle line extraction.

1. INTRODUCTION

Palmprint is one of the most reliable features in personal identification because of its stability and uniqueness [1] [2]. The inner surface of the palm normally contains three flexion creases, secondary creases and ridges. The flexion creases are also called principal lines and secondary creases are called wrinkles. Many feature of a palmprint can be used to uniquely identify a person. Six major types of features can be observed on a palm (figure 1). Palmprint recognition consists of images acquisition in which image is capture with the help of device. Preprocessing is to setup a coordinate system to align palmprint images and to segment a part of palmprint image for palmprint feature extraction. One key feature in palmprint identification is deciding how the image is to be taken for identification purposes. The images taken generally involve the entire hand of the subject. The problem with using the entire hand is that the area of the hand except for the palm can also be included in the identification process. In some cases, this may lead to obfuscation of the image and thus, may lead to faulty identification. One way to resolve this issue is by cropping the entire image to give that area of the image which contains the palm itself. This area is termed the ROI. The main problem in palmprint recognition system is how to extract the ROI and the features of palmprint. Most of the preprocessing algorithms segment square regions for feature extraction but some of them segment circular and half elliptical regions. The square region is easier for handling translation variation, while the circular and half elliptical regions may be easier for handling rotation variation. This paper focuses on problem based on the pre-processing section which is important in providing high accuracy in pattern recognition. Many papers which have discussed about preprocessing and feature extraction, So we discuss and give more attention to an individual part of an preprocessing because until we can't get a proper ROI region, we will unable to get high accuracy further.

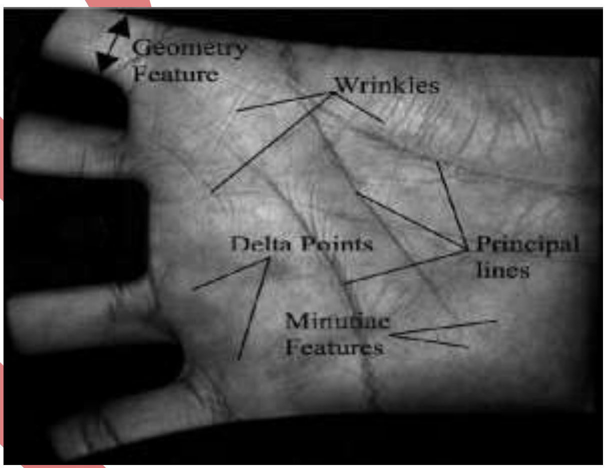


Fig.1 Different Features of Palm.

The remaining section is organized as follows: Section 2 gives the details about the acquisition of palm images. Section 3 describes survey of various methods of segmentation of ROI which are used previously. Finally section 5 gives the discussion and conclusions.

2. PALMPRINT ACQUISITION

During image acquisition a palmprint image is captured by a palmprint scanner or camera and store in grayscale file. Then the AC signal is converted into a digital signal, which is transmitted to a computer for further processing. It is the first process in palmprint recognition systems. Researchers utilize four different types of sensors to collect palmprint images, CCD-based palmprint scanners, digital cameras, digital scanners and video cameras. A CCD-based palmprint scanner developed by the Hong Kong Polytechnic University.

Fig.2 A CCD-based palmprint scanner.

3. VARIOUS METHODS FOR EXTRACTION OF ROI

There are many schemes were proposed toextract the ROI in palmprint images. In this paper survey maximum numbers of different methods of finding the ROI is discussed.

Zhang D., Kong W.K., You J., Wong M [3] proposed a new technique which uses the gaps between the fingers as reference points to determine a coordinate system, it is important to define a coordinate system that is used to align different palmprint images for matching. To extract the central part of a palmprint, for reliable feature measurements, the five major steps (see Fig. 3) in processing the image are:

Step 1: Apply a lowpass filter, L(u, v), such as Gaussian smoothing, to the original image, O(x, y). A threshold, Tp, is used to convert the convolved image to a binary image, B(x, y), as shown in Fig. 3(b).

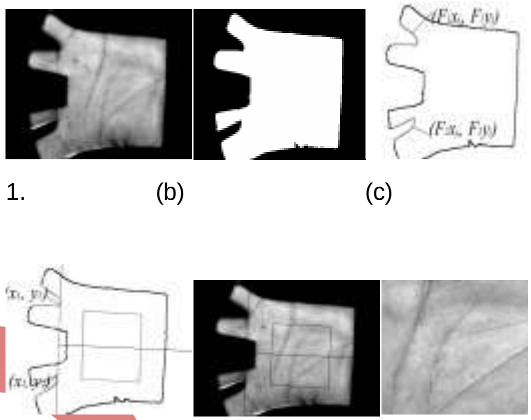
Step 2: Obtain the boundaries of the gaps, (Fixj, Fiyj) (i=1, 2), between the fingers using a boundary tracking algorithm (see Fig. 3(c)). The boundary of the gap between the ring and middle fingers is not extracted since it is not useful for the following processing.

Step 3: Compute the tangent of the two gaps. Let (x1, y1) and (x2, y2) be any points on (F1xj, F1yj) and (F2xj, F2yj), respectively. If the line (y= mx+c) passing though these two points satisfies the inequality, Fiyj = mFixj + c, for all I and

j(see Fig. 3(d)), then the line (y =mx + c) is considered to be the tangent of the two gaps.

Step 4: Line up (x1, y1) and (x2, y2) to get the Y-axis of the palmprint coordinate system, and use a line passing through the midpoint of these two points, which is perpendicular to the Y-axis, to determine the origin of the coordinate system (see Fig. 3(d)).

Step 5: Extract a sub-image of a fixed size based on the coordinate system. The sub-image is located at a certain area of the palmprint image for feature extraction (see Figs. 3(e)-(f)).



1. (b) (c)

(d) (e) (f)

Fig. 3 Locate ROI: (a) infrared palm image captured by our device (b) binarized image (c) boundaries (d) and (e) ROI locating (f) the subimage in ROI.

C. Poon, D.C.M. Wong, H.C. Shen [4] proposed new method for extraction of ROI. The setting of their system is such that they employ a contact-less capturing system that works without pegs. The background of the image is relatively uniform and is of a relatively low intensity when compared to the hand image. Using the statistical information of the background and that of the rest of the pixels, the algorithm estimates an adaptive threshold to segment the image of the hand from the background. To ensure the extracted palm region has minimal rotation and translation error, the algorithm identifies gaps-between-fingers and uses them as reference points to align the image. By levelling the gap between the index finger (IF) and the middle finger (MF), and that between the MF and the ring finger (RF), images of the palm are aligned rotationally. Since the gap between MF and RF is usually the most robust point amongst the three gaps, it is used as the reference point to eliminate translation error (Fig.4-a). The maximum square region that can fit in the selected palm area is chosen as the ROI. The square region is horizontally centred on the axis running through the gap between MF and RF. In addition, since the ROI will be divided into non-overlapping elliptical half-rings, the size of the region must be divisible by the width of each elliptical layer (50 pixels in this study) (Fig.4-b).

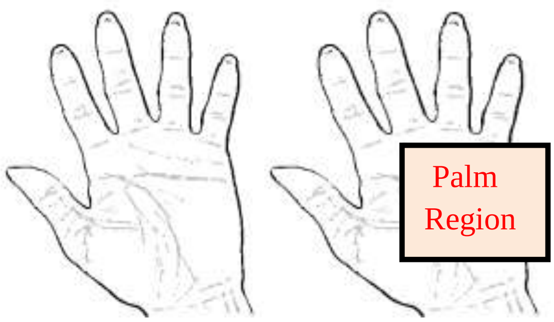


Figure 4(a): Schematic diagram of image alignment

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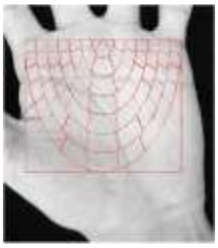


Figure 4(b): Segmentation of ROI

Leqing Zhu, Sanyuan Zhang, Rui Xing, Yin Zhang [5], The image preprocessing includes: grayscale enhancement, fixing the center point C of the palm, finding out the referent point O between the middle finger and ring finger, rotating the image round O until the line OC is horizontal, the smooth filter is also included before the binarization. Grayscale enhancement is realized by linear grayscale stretching, highlights are eliminated before enhancement so as to diminish the interference of uneven illumination. The palm center C is fixed by finding out the maximum inscribed circle of the palm as introduced in [15]. The referent point O is fixed with the method introduced in [16]. The processed result is shown as figure 5. The outline of valid region and referent point O is highlighted with white.

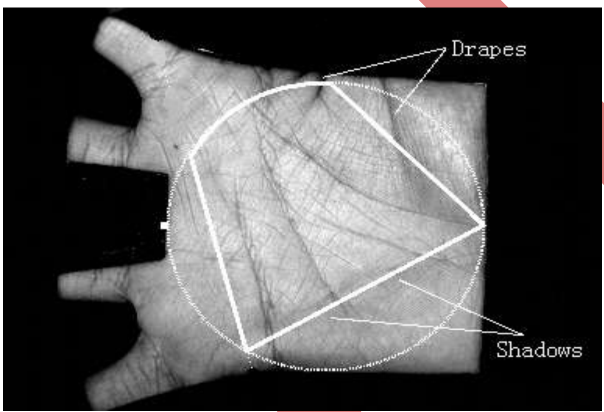


Fig. 5 Fixing valid palmprint region.

W. K. Kong, D. Zhang, W. Li [6] proposed 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. 6):

Step 1: Apply a low-pass filter to the original image. Then use a threshold, Tp, to convert this original image into a binary image as shown in Fig. 6(b). Mathematically, this transformation can be represented as

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

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

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.

Step 2: Extract the boundaries of the holes, (Fixj, Fiyj) (i = 1, 2), between fingers using a boundary-tracking algorithm. The start points, (Sxi, Syi), and end points, (Exi, Eyi) of the holes are then marked in the process (see Fig. 6(c)).

Step 3: Compute the center of gravity, (Cxi, Cyi), of each hole with the following equations:

$$Cxi = \frac{\sum_{j=1}^{M(i)} Fixj}{M(i)} \qquad (3)$$

$$Cyi = \frac{\sum_{j=1}^{M(i)} Fixj}{M(i)} \qquad (4)$$

Where, (Mxi, Myi) is the midpoint of (Sxi, Syi) and (Exi, Eyi). Based on these lines, two key points, (k1, k2), can easily be detected (see Fig. 6(d)).

Step 4: Line up k1 and k2 to get the Y -axis of the palmprint coordinate system and make a line through their midpoint which is perpendicular to the Y-axis, to determine the origin of the coordinate system (see Fig. 6(e)). This coordinate system can align different palmprint images.

Step 5: Extract 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. 6(f)).

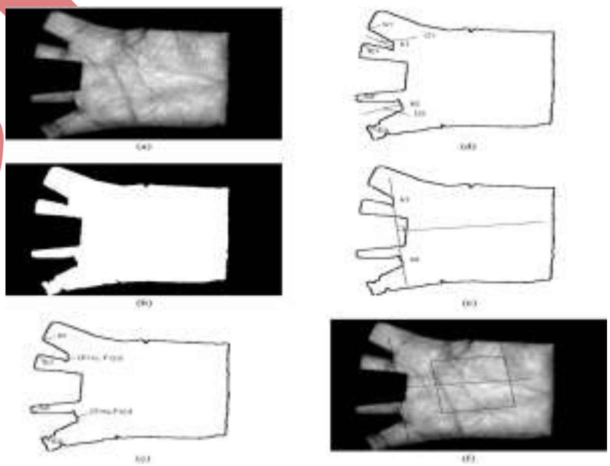


Fig.6 Main steps of preprocessing: (a) original image, (b) binary image, (c) boundary tracking, (d) key points (k1 and k3) detecting, (e) the coordinate system and (f) The central part of a palmprint.

Chin-Chuan Han, Hsu-Liang Cheng, Chih-Lung Linb, Kuo-Chin Fan [7], proposed approach of four steps are devised in the pre-processing module. Image thresholding, border tracing, wavelet-based segmentation, and ROI location are sequentially executed to obtain a square region which possesses the palm-print data. Steps for finding ROI are as follows:

Step 1: Image thresholding.

Step 2: Border tracing.

Step 3: Wavelet-based segmentation.

Step 4: ROI generation: In this step, it will find the ROI in the palm table as shown in Fig. 7 which is the operating region both in the enrolment and verification processes. In acquiring the hand images, the hands were freely put on the plate-form scanner at any position and in any direction. Fortunately, when users put their hand on the input devices in normal condition, the direction of a hand is consistent with the principal axis which is the center line of middle finger. According to the result generated in Step 3, the location of ROI is determined from points Pa, Pb, P3, and the geometrical formula. Two points Pa and Pb are the base points to generate the ROI. First, the middle point P0 is calculated from points Pa and Pb. Then, the principal axis $\overline{POP3}$ is obtained which is the center line of middle finger perpendicular to line $\overline{PaPb}$. The principal axis P0P3 is then extended to point Pe, where $|\overline{POPe}| = |\overline{PaPb}|$. From point Pe, the two perpendicular bisector lines denoted as $\overline{PePe2}$ and $\overline{PePe1}$, whose length equals 128 pixels, are found. Based on this section line $\overline{Pe1Pe2}$, the square region Pe_1 Pe_2 Pe_3 Pe_4 of size 256 by 256 is defined as the ROI, as shown in Fig. 7(a). From these four points, the image of ROI is cut from the hand image as shown in Fig. 7(b).

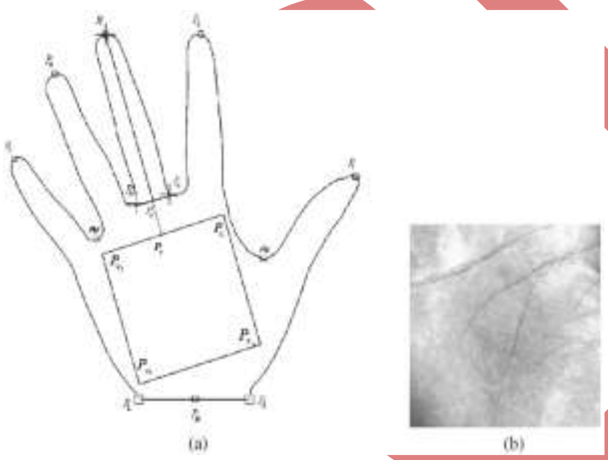


Fig. 7 Generation of ROI.

Tee Connie, Andrew TeohBeng Jin, Michael GohKahOng, David Ngo Chek Ling [8], in this system, no guidance pegs are fixed on the scanner's platform and the users are allowed to place their hands freely on the platform of the scanner when scanned. Thus, palmprint images with different sizes, shifts and rotations are produced. Therefore, a pre-processing algorithm has been developed to correct the orientation of the images and also convert the palmprints into same size images. The ROI is defined in square shape and it contains sufficient information to represent the palmprint for further processing. Fig. 3 depicts the appearance of ROI of a palm. We applied the salient-point detection algorithm proposed by Goh et al. [17] to obtain the three crucial points, v1, v2 and v3 as shown in Fig. 3, used to locate the ROI. First, an image thresholding technique is applied to segment the hand image from the background. The proposed technique can also detect fingernails and rings by analyzing the skin color of the hand. The hand image acquired is in 256-RGB colors with stable background in grey. The background can be segmented based on the values of the image's color component r, g, and b which represent red, green and blue, respectively. The image thresholding technique proposed is

$$C1(u,v) = \begin{cases} 1, & |r(u,v) - b(u,v)| < T \\ 0, & \text{otherwise} \end{cases} \quad (5)$$

Eq. (1) is repeated for setting, $|r(u,v) - b(u,v)|$, yielding C2(u,v) and, $|b(u,v) - g(u,v)|$, C3(u,v). The threshold value T is set to 50 to filter all the grey level color to white and other color to black. The resultant image of binary pixel C1, C2 and C3 are ANDed to obtain the binary image,

$$I=\sum_{v=1}^{h}\sum_{u=1}^{w}\bigcap_{i=1}^{3} Ci(u,v) \quad (6)$$

After that, contour of the hand shape is obtained by using eight neighborhood border tracing algorithm [19]. The process starts by scanning the pixels of the binary image from the bottom-left to the right. When the first black pixel is detected the border tracing algorithm is initiated to trace the border of the hand in clockwise directions. During the border tracing process, all the coordinates of the border pixels were recorded in order to represent the signature of the hand, f(i) where i is the array index. The hand signature is blocked into non-overlapping frames of 10 samples, f(i). Every frame is checked for existence of stationary points and in this way the valleys of the fingers, v1, v2 and v3 could be pinpointed. Based on the information of these three crucial points, the outline of the ROI could be obtained as follows:

Step 1: The two valleys beside the middle finger, v1, v2, are connected to form a reference line.

Step 2: The reference line is extended to intersect the right-edge of the hand.

Step 3: The intersection point obtained from step (2) is used to find the midpoint, m1, based on the midpoint formula.

Step 4: Steps (1) to (3) are repeated to find the other midpoint, m2, by using the valleys v2, v3.

Step 5: The two midpoints, m1 and m2, are connected to form the base line to obtain the ROI.

Step 6: Based on the principal of geometrical square where all the four edges having equal length, the other two points,m3 and m4, needed to form the square outline of the ROI can be obtained (refer Fig. 8(a)).Fig. 8(b) shows some examples of the ROIs extracted from different individuals, obtained from both the right and left palms.

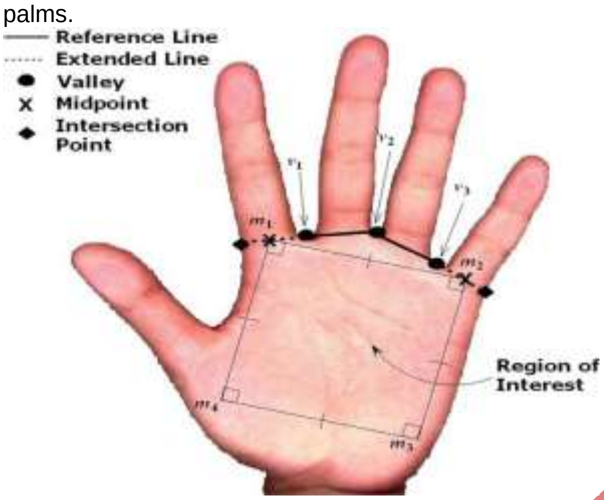


Fig.8(a) Outline of ROI from the palm.

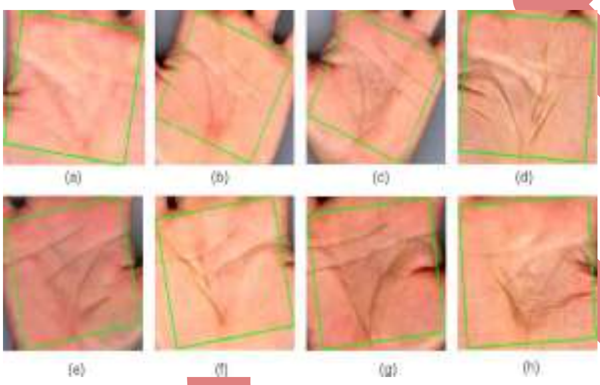


Fig.8 (b). ROIs obtained from different individuals. They have different sizes and rotations. (a), (b), (c) and (d) depicts ROI from the right palms from four individuals, while (e), (f), (g) and (h) are ROIs from the left palms from another four individuals.

Yi Feng, Jing wen Li, Lei Huang, And Changping Liu [9] proposed some methodology for segmentation of ROI, They use the mean distance between all hand key point pairs to respect the scale of palm. Then we can get a ROI of variable size depend on the palm scale, which is robust to the different poses and scales. As Fig.9 shows, according to the position of P^1 P^2 P^3 P^4 it judge whether it is the right hand or a left hand. Then the key point C^1 between middle finger and index finger, the key point C^2 between middle finger and ring finger, and the key point C^3 between ring finger and pinky finger are located. The steps on obtaining the square area ROI are described as follows:

1) Line up C^1 and C^3 to get the X-axis of image and then make a line through C^2, perpendicular to the Y-axis, and the intersection is d^1.

2) Calculate the mean δ distance between the points C^1, C^2, C^3 and make

$$d^1d^2 = \frac{\delta}{2} \quad (7)$$

3) Locate the square $a^1a^2a^3a^4$, a^1a^2 and C^1C^3 are parallel, make

$$a^1a^2 = \delta \times \frac{3}{2}, \quad \frac{a^1d^2}{d^2a^2} = \frac{C^1C^2}{C^2C^3} \quad (8)$$

4) Get the ROI image from the original image, and transform it into a grey image of fit size.

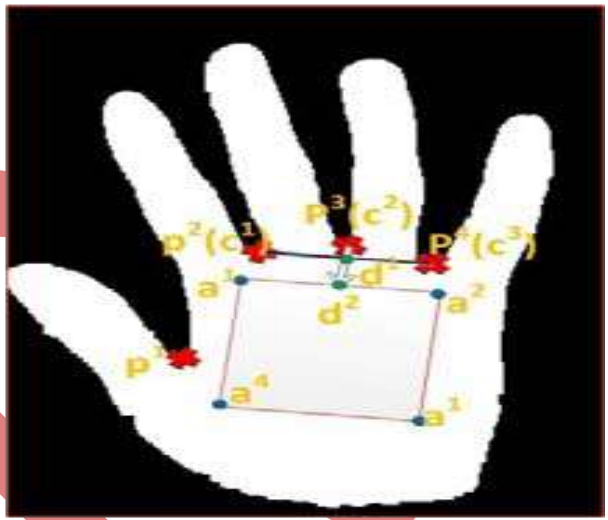
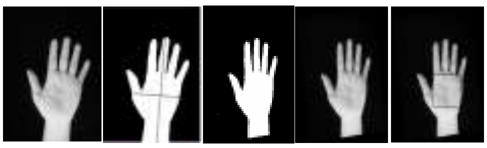


Fig.9 Locate the ROI of palm with key points.

Ajay Kumar, David C. M. Wong, Helen C. Shen, Anil K. Jain [10] Every binarized hand-shape image is subjected to morphological erosion, with a known binary structuring element (SE), to compute the ROI, i.e., the palmprint. Let R be the set of non-zero pixels in a given binary image and SE be the set of non-zero pixels, i.e., structuring element. The morphological erosion is defined as

$$R\ominus SE = \{g : SE_g \subseteq R\} \quad (9)$$

Where,SEgdenotes the structuring element with its reference point shifted by g pixels. A square SE is used to probe the composite binarized image. The center of binary hand image after erosion, i.e., the center of rectangle that can enclose the residue is determined. This center coordinates are used to extract a square palmprint region of fixed size as shown in figure 10.



(a) (b) (c) (d) (e)

Fig. 10 Extraction of two biometric modalities from the hand image, (a) captured image from the digital camera, (b) binarized image and ellipse fitting to compute the orientation (c) binary image after rotation, (d) gray scale image after rotation (e) ROI, i. e., palmprint, extracted from the center of image in (c) after erosion.

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I KetutGedeDarma Putra, Erdiawan [11] proposed and implement proposed method for segmentation of palmprint ROI. In this new technique to extract the ROI is called two steps in moment central method. The steps of the method can be explained as follow:

Step 1: The gray level hand image is threshold to obtain the binary hand image. The threshold value is computed automatically using the Otsu method. To avoid the white pixels (not pixel object) outside of the hand object is used median filter.

Step 2: Each of the acquired hand images needs to be aligned in a preferred direction so as to capture the same features for matching. The moment orientation method is applied to thebinary image to estimate the orientation of the hand. In the method, the angle of rotation (q) is the difference between normal axis and major axis of ellipse that can be computed as follows.

$$\theta = \frac{1}{2}\tan^{-1}\left[\frac{2\mu_{1,1}}{\mu_{2,0}-\mu_{0,2}}\right] \qquad (10)$$

$$\mu_{p,q} = \sum_m \sum_n (m-\bar{m})^p (n-\bar{n})^q \qquad (11)$$

Where $\mu_{p,q}$ represent the (p, q)th moment central, and $(\bar{m},\bar{n})$ represents center of area is defined as

$$\bar{m} = \frac{1}{N}\sum_m \sum_n m, \quad \bar{n} = \frac{1}{N}\sum_m \sum_n n, \qquad (12)$$

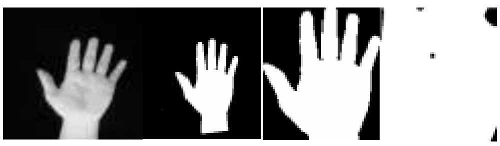
Where N represent number of pixel object. Furthermore, the grayscale and the binary image are rotated about (Θ) degree.

Step 3: Bounding box operation is applied to the rotated binary image to get the smallest rectangle which contains the binary hand image. The original hand image, binarized image, and bounded image shown in Figure 11 (a), (b), and (c), respectively.

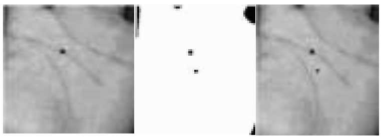
Step 4: The centroid of bounded image is computed using equation (12) and based on this centroid, the bounded binary and original images are segmented with 200x200 pixels. Thesegmented image and its centroid position are shown in Figure 11 (d) and (e).

Step 5: The centroid of the segmented binary image is computed and based on this centroid the ROI of grayscale palmprint image can be cropped with size 128x128 pixels. The first and the second positions of centroid in binary and gray level image are shown in Figure 11 (f) and (g).

This method is simple. This method has been tested for 1000 palmprint images acquired from 200 persons, and the results show this method is reliable.



(a)(b) (c) (d)



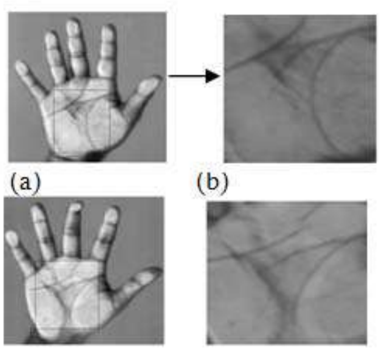
(e) (f) (g)

Fig. 11 (a) original image, (b) binary image of (a), (c) object bounded, (d) and (e) position of the first centroid mass in segmented binary and gray level image, respectively, (f) and (g) position of the second centroid mass in segmented binary and gray level image, respectively.

S. Kanchana, G. Balakrishnan [18] proposed a method to find a way to distinguish palm region from fingers and background. To detect the palm region, region-based segmentation method is attempted to group pixels according to the criterion of homogeneity of regions such as Intensity, Gray level, Color, Textures, Shape, etc. Here, the thresholding simplicity and the spatial information have been considered as similarity constraint. For all the pixels, both the characteristics are computed. The probability for a pixel to belong to the region can be obtained by satisfying the similarity constraint:

H (Ri) = True, i=1, 2…N (13)

Finally, the maximum connective texture region has extracted as Region of Interest which ensures the reliability of the segmentation and provides the ability to resist noise.



(a) (b)

Fig. 12 (a) palm region identified from two different hand images (b) Extracted ROI from the palm image for the corresponding

4. CONCLUSIONS

In this paper, a various methods of palm selection and extraction of ROI are discussed. ROI segmentation of palm is to automatically and reliably segment a small region from the captured palm image, it is very important step of palmprint recognition because it greatly influences the accuracy and processing speed of the system. All various methods of extraction of ROI are useful by considering various constraints provide very good and accurate results.

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