ROI Extraction for Palm print Using Local Thresholding, Region Growing and Geometrical Centroid Criterion By

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Abstract

One of the most important steps have great impact on the results in general are, in particular, the steps follow the extraction of the area of interest; they was not clearly introduced by other articles. So, this article aims to present a proposed method for automated extraction of hand palm region of interest; it includes (i) hand palm image enhancement (smoothing) to reduce the effectiveness of noise, (ii) applying adaptive Otsu's method for local thresholding, (iii) using flood-fill algorithm for region growing to collect the hand palm lines. Some extra steps were applied to remove the small linear objects or the small patches which are appeared due to thresholding errors those due to the local brightness non-uniformity that existing in the most regions of palm area. Also, the introduced method includes the detection of geometrical centroid of the palm ROI and considering the central palm virtual circle covers the most discriminating region of the tested palm. The results of the tests conducted on the public CASIA Palmprint (consists of 5502 images) indicated that the accuracy rate of the palm allocation area is 99.96%.

Key Words: Region of interest (ROI), Palmprint localization, ROI, Local Enhancement, OTSU Algorithm Applications.

Introduction

The Region of Interest (ROI) extraction of palm area is a crucial step in automatic hand palmprint biometric and biomedical systems. The recognition process depends firstly on the accuracy degree of ROI extraction process. However, the extraction is affected by several factors, mainly including the device used and the acquisition conditions. The acquisition mode can be effected by several image conditions like rotation, translation and scale. Most of the previous studies failed to achieve high extraction rates for the palm area.

It this research project, the developed method was implemented on CASIA Palmprint [1]. This image database consists of 5,502 images captured from 312 persons. For each person, the collected palm print images are for both left palm and right palm, all enrolled palm print images are JPEG files and each pixel in images 8 bit gray-level.

Yan [13] presented a robust approach for localizing the palm and extracting the ROI based on real-time region learning. It was tested on 1000 samples of video clips of hand taken under different illumination and poses, the accurate extraction rate reaches 92%. Boa and Guo [15] used the convolutional neural networks for palmprint (ROI) extraction; the core idea is employing the valley points between the fingers to establish a coordinate system and then obtain the ROI of palmprints.

Madasu [3] discussed the process of extraction the hand palm area of interest; he considered some improvements in the preprocessing stage for improving authentic-ation process. The Region of interest (ROI) is extracted from the palmprint image by finding a tangent curve between fingers. The perpendicular bisector of this tangent divides the rectangular area enclosure of palm print into two equal parts. The palmprint image is acquired using an acquisition system that developed at IIT Delhi.

Gao and et al. [14] propose a method based on using key points for extracting palm ROI. They tested the validity of their method using both PloyU database and CASIA database, and the results were promising. Z. Gao, Y. Ding, H. Wang and J. Wang, proposed "A New Way for Extracting Region of Interest from Palmprint by Detecting Key Points.

Some, ROI extraction methods were proposed in the literature, most of them are based the work of Wen L. I. [6], filter based method introduced by D. Zhang [7], and inscribed-circle method for Guo X [8], and Concavity Analysis method for X. Sun [9]. All the four previous method were tested using the two public databases CASIA database [1] and PolyU database [2].

The rest of this paper is organized as follows: Section 2 Introduced Extraction Process of Hand Palm region of interest. Section 3 is dedicated to describe the introduced palm print allocation method. The experimental results have been clarified in Section 4. While section 5 lists the derived conclusions of this research project.

2. The Introduced Extraction Process of Hand Palm ROI

The general framework of introduced ROI extraction process is shown in Figure (1). Also, Figure 2 presents samples of the palm print images. To accurately allocate the palm region many complementary steps should applied. The system starts from converting the hand palm image to gray variants, then to binary including only the hand line only.

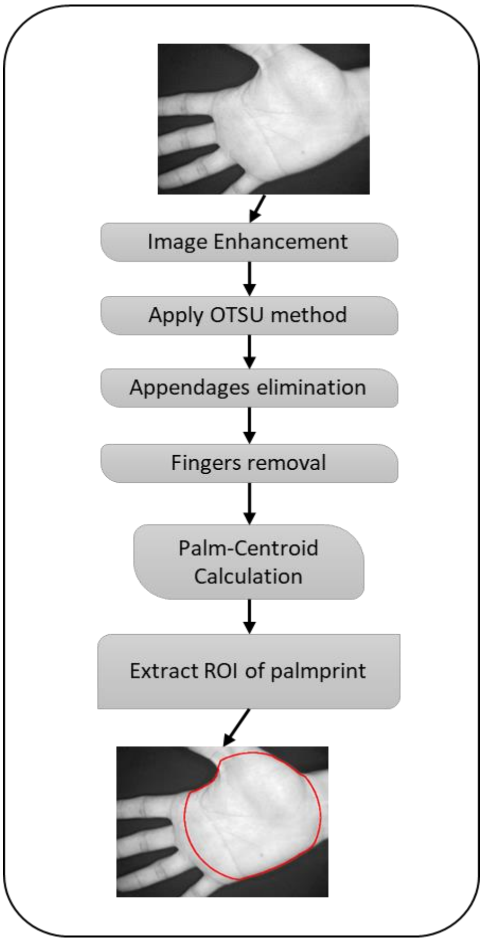


Figure 1: The layout of introduced palm ROI allocation system

This conversion process implies the steps of removing the fingers areas, removing the noise caused due to segmentation failures, the determining the center of the palm to extract palm ROI. In the following this conversion process implies the steps of removing the fingers areas, removing the noise caused due to segmentation failures; then, determining the center of the palm to extract palm ROI. In the following some details about each step is given.

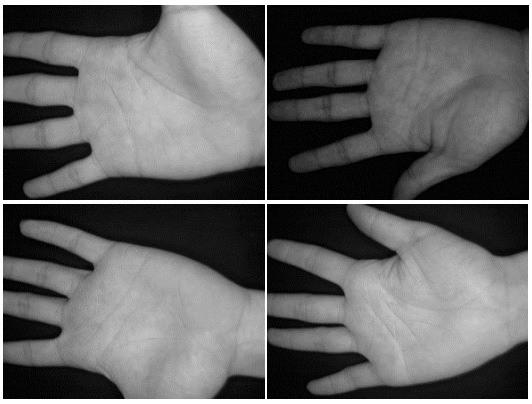


Figure 2: samples from CASIA-Palmprint database.

2.1 Hand Palm Image Enhancement

This process aims to adjusting the input images to be more proper for further image analysis. For enhancing the hand palm image the mean filter with 3×3 square kernel was applied for reducing noise in an image. Then contrast stretching is applied as an enhancement technique, instead of linear stretching to enhance the contrast level of the image, the enhanced gamma mapping function is applied:

$$G_{out}(x,y) = 255\left(\frac{G_{in} - G_{min}}{G_{max} - G_{min}}\right)^{\gamma} \qquad (1)$$

Where,

G_{in} : gray level input pixel
G_{out} : gray level output pixel
G_{min} : Minimum gray level of the input image
G_{max} : Maximum gray level of the input image
γ : gamma parameter.

Before, applying the mapping process depending of the actual min & max boundary values of the noise input image, it effective range of the gray values is assessed depending on range at which the majority of the gray image values are concentrated. To do this assessment the mean (μ) and standard deviation (σ) values of gray image are determined; then, the effective G_{min} & G_{max} values are determined by using the below equations:

$$\mu = \frac{1}{wh}\sum_{y=0}^{h-1}\sum_{x=0}^{w-1} Img(x,y) \qquad (2)$$

$$\sigma^2 = \frac{1}{wh}\sum_{y=0}^{h-1}\sum_{x=0}^{w-1} (Img(x,y) - \mu)^2 \qquad (3)$$

$$G_{min} = \boldsymbol{\mu} - \alpha_1 \times \sigma \qquad (4)$$

$$G_{max} = \boldsymbol{\mu} + \alpha_2 \times \sigma \qquad (5)$$

Where, α_1 & α_2 are multiplies to represent the degree of gray levels deflection from the mean at the dark side and bright side of the image. The conducted comprehensive tests' results indicated that the proper value for both α_1 & α_2 is 1.7, 1.8, respectively, and for γ is 0.77.

The mapping equation (1) was modified to handle the bounding constraints {G_{min}, G_{max}}, such that is becomes in the form:

$$G_{out}(x,y) = \begin{cases} 0 & if\ G \le G_{min} \\ 255\left(\frac{G(x,y) - G_{min}}{G_{max} - G_{min}}\right)^{\gamma} & if\ G_{min} < G < G_{max} \\ 255 & if\ G \ge \end{cases} \qquad ....(6)$$

In order to remove the local variation of brightness that has intermediate scale the following mean compensation mapping step was introduced:

$$G'_{out}(x,y) = G_{out}(x,y) - \bar{G}_{out}(x,y) + 128 \qquad (7)$$

Where, $\bar{G}_{out}$(x,y) is the local mean of the neighbors surrounding each pixel:

$$G'_{out}(x,y) = \sum_{j=-L}^{L} \sum_{i=-L}^{L} G_{out}(x+i, y+j) \quad (8)$$

Equation (7) ensures that the local mean become 128; in such case the local variation will be reduced to some extent, this depends on choosing the suitable value of L.

2.2 Binarization

Simply, the value of pixels in gray image ranging from 0 to 255 to convert it into binary image with values of pixels {0,1}. Thresholding techniques used to convert Image from gray scale to binary and this method mainly used in segmentation. This method done by replace each pixels in image with black and white depend on threshold value (T).

1) Finding the Optimal Threshold

There are two basic types of thresholding methods: (i) global and (ii) local image thresholding, in this work the local (adaptive) thresholding that proposed by OTSU [4] was used. OTSU method is applied on the outcome G_{out} of equation (7); in this step the background points (i.e., with black color) are excluded in order to give optimal adaptive value without any effect.

2) Apply binarization

It is straightforward steps, aims to convert gray image to produce a binary image {0, 1}, it is done after get optimal threshold value from previous step.

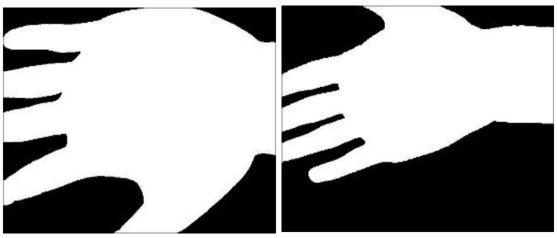


Figure 3: Samples of binary step on hand palm images

2.3 Remove the Appendages

To more precisely allocate the active hand palm region with white color and black background all hand appendages, which are out of central area of hand palm, beside to noise areas (gaps) appeared in palm body area must be removed. The erosion morphological operation was used to remove the noise small areas in order get smooth outer boundary for hand palm mask.

Then, the flood-fill algorithm (also called seed filling) was applied; it takes three parameters: (i) position of seed point, (ii) the target color, and (iii) and the replacement color. it is search algorithm for all connected points based on specific color and change it to another one , also search for neighbors pixels {upper, lower, left, right} of own pixel. and all pixels in binary level i.e. all pixels values {0,1}, proposed method used this algorithm to remove all gaps inside hand palm mask and remove all white gaps outside hand palm mask.

2.4 Remove fingers

This step is the most important step in the proposed method, because it removes the outer parts of the hand area (i.e., white areas) that have no importance and are outside of palm area (i.e., ROI). So, the fingers and wrist area are removed. This task is simply accomplished using scanning a method enrolled by threshold value for the runs length of white pixels.

Two scans are conducted, the first one is a moving vertical scan starts from top to bottom and growling from left to right, while the second scan is a crawling horizontal scan moving from top to bottom, these two scans aim to define the top-left and bottom-right corners of the hand region holds the flagged

(1's) pixels in the produced binary image. At each line/column scan instance the number of flagged pixels is counted, and if the number in pixels is more than a pre-define threshold number (p), it this work its value set 2, then the line status flag is set "nonempty" otherwise it is flagged "empty"; then after finishing the scan round the terminal points of the flag status array are consider the region boundaries coordinated (left or right for horizontal scan or top-bottom for vertical scan). Figure (4) presents a sample of the bounded ROI using the proposed scan method.

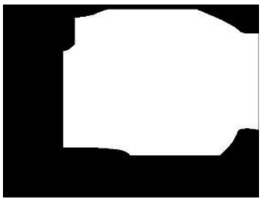


Figure 4: palm image fingers removal.

2.5 Palm-Centroid Calculation

In this step the center of point of the palm is determined using the center of mass definition; it is done by find mean of white pixels in recently part was produced from previous step, as below equations:

$$X_c = \frac{1}{N}\sum_{i \in S} x_i \ , \ Y_c = \frac{1}{N}\sum_{i \in S} y_i \qquad (9)$$

Where, (X_c, Y_c) are the coordinates of the center of gravity of palm; S is the set of flagged (1's) points in the binary image; N is the number of points (x_i,y_i) belong to S.

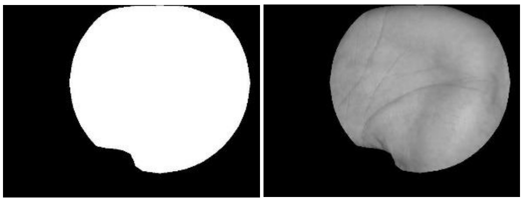
As next step, the area of circle bounding the region of interest is assessed by determining the area of white area, which is the number (N) of flagged (1's) points. The radius (R) can be assessed using the following equation:

$$R = \sqrt{\frac{N}{\pi}} \qquad (10)$$

As final step, a refinement for the area allocation is done by conducting 8 scans, to resize the produced virtual circle, the eight scans are toward the directions (0^o, 45^o, 90^o, 135^o, 180^o, 225^o, 270^o, 315^o); so according to these scans the shapes of the binary area is slightly adjusted to change its shape from circular to polygon shape which have more fitness to the shape of palm.

2.6 Allocation of Palm Region

This is the last step in this proposed method, it implies the application of seed filling method to collect only the points lay inside the defined hand polygon produced in the previous stage. Figure (5) presents the final result of palm extraction region.



a. Binary mask b. Gray ROI

Figure 5: Allocation of palmprint region

3. Experimental Result

In this section, the results of some conducted tests are given to present the accuracy of the introduced system.

3.1 Allocation Accuracy

For testing purpose, the low resolution CASIA Palmprint Image Dataset was adopted as testing material. It is consist of 5,502 palmprint images captured from 312 subjects. For each subject, two sub-sets of palmprint images were taken for both the left and right hands (8 sample or more for each).

The samples were taken under uniform-colored background; all images are saved as 8 bit gray-level JPEG files.

Figure (6) presents different samples of the proposed palm region allocation method, the results indices that method performance is promising and the output could be utilized as input for cognition (verification or recognition) tasks.

As an objective measure for accuracy assessment the first order statistics of the individual scatter ratio for the determined effective radii which are determined from the handpalm samples belong to each individual alone. The effective radius is determined using equation (7), and the scatter ratio (Sc) of the individual (i) is determined using the following equation:

$$Sc(i) = \frac{StDev_{j=1..m}\left(r_{eff}(i,j)\right)}{Mean_{j=1..m}\left(r_{eff}(i,j)\right)} \qquad (11)$$

Where, $r_{eff}(i,j)$ is the calculated radius using equation (7) for sample (j) that belong to subject (i); (m) is the number of samples belong to subject i. The operators Mean and StDev represent the mean and standard deviation for r_{eff}.

The determined first order statistics values for scatter ratios over all individuals are listed in table (1). The values indicate that the degree of allocated hand palm area is high.

Table (1) the Mean and StDev of the Scatter Ratio for the determined hand palm radii

Mean of S()	0.0218
Median of S()	0.0179
StDev of S()	0.0169
Min od S()	0.0022
Max of S()	0.1456

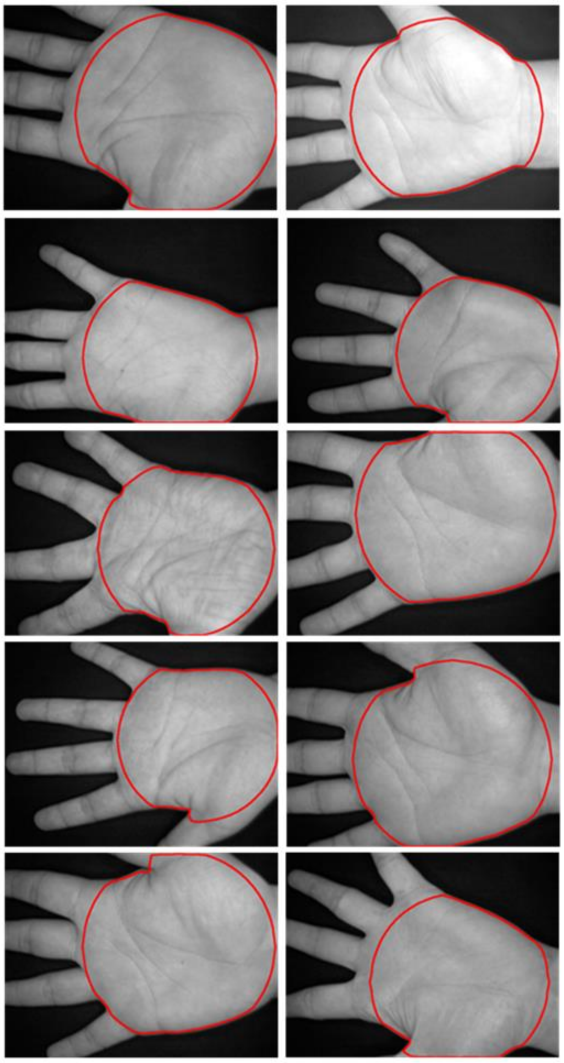


Figure (6) Illustrative output examples of the proposed palmprint ROI allocation method

3.2 Processing Time

The system was implemented using Visual studio C# 2015 on a PC with operating system is Windows 10, processor is ci7-7500u CPU (2.70 GHz), and 16-GB random access memory. The execution time for the proposed method is less than 0.2s, which is fast enough for real-time applications. By optimizing the program code, it is possible achieve further reduction in the computational time.

4. Comparison with Other Methods

In order to evaluate the performance of the introduced method; and to prove it has better performance in comparison with those given in the literature.

Zhong and et al. [10] tested only 2000 images of the database and results indicated accuracy rate of automatic positioning of ROI, approximately 97.8%. While, Kekre and et al. [11] applied their experiments on only 2009 images belong to the same database and obtained an accuracy rate of automatic positioning of ROI, approximately 100%.

For the proposed method in this research paper, the number of tested images is 5502 images (i.e., the whole samples listed in the dataset). The attained accuracy for allocating the hand palm ROI, is 99.96% (which means 5500 images). Mokni, et al. [12] conducted their experiments on the same database and the obtained accuracy rate of automatic ROI allocation was, approximately, 98%. Table (2) summarized the abovementioned results.

Table 2: illustrate accuracy rate for our method with other method

Method	Number of images in Database	Correct position ROI images	Accuracy Rate of automatic position
Zhong	2000	1965	97.8%
Kekre	2009	2009	100%
Mokni	5502	5392	98%
Our	5502	5500	99.96%

5. Conclusion

This paper introduces an effective and fast method for extracting the handpalm region of Interest. The method implies the use of hand palm image enhancement (smoothing) which can remove the noise and eliminate the holes curve, the adaptive Otsu's method, the flood-fill algorithm. Also, it includes the detection of palm ROI and represents it by centroid point and virtual circle. To achieve high cognition accuracy the whole palm area is defined by collecting the largest number of palm points; this will be useful to extract all useful hand palm geometrical features for recognition/authentication purpose.

The attained results indicated that the proposed method is promising and fast and very suitable as a preliminary stage in recognition/verification applications. The next orientation is to focus on using the palm region allocation for more complicated biometric applications. Also, some changes should be done to make the introduced method faster for any kind of hand palm images.

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