Region of interest extraction for palmprint and palm vein recognition

Conference Paper · October 2016

DOI: 10.1109/CISP-BMEI.2016.7852769

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Region of Interest Extraction for Palmprint and Palm Vein Recognition

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Abstract—**The ROI (region of interest) extraction is the key step in palmprint or palm vein recognition, which is very important for the subsequent feature extraction and recognition. In this paper, the ROI extraction method for palmprint and palm vein recognition is mainly studied. Firstly, the preprocessing operation of palmprint and palm vein is carried out by using binary and morphological denoising technology, then the ROI regions are located and extracted based on the maximum inscribed circle and centroid methods. Finally, the algorithms are tested on PUT palm vein database and CASIA database, the experimental results show that the methods of this paper have a good effect, which are feasibility and validity. Furthermore, an online ROI extraction simulation system is designed in this article. The palmprint or palm vein image can be obtained in real-time by using the camera through the system, then the ROI can be extracted. The simulation system is intuitive and easy to operate, which provides a reliable experimental platform for the study of palmprint and palm vein recognition technology.**

Keywords-region of interest; palmprint; palm vein; centroid; maximum inscribed circle

I. INTRODUCTION

Palmprint recognition [1-2] is based on the effective texture information on the palm of the hand for identification, and the palm vein recognition [3-4] is according to the information of vein blood vessel under the palm skin layer. The ROI extraction is a hot issue for the palmprint and palm vein identification. The ROI extraction refers to carrying out a series of adjustment and key points location for different palmprint and palm vein images, then the effective area of center is selected to extract features, and final matching is carried out for the recognition. This central region is usually called the region of interest (ROI), for the palmprint and palm vein image of the same palm, the location of ROI should be the same. The purpose of ROI location and selection is to do the feature area normalization of the different palmprint and palm vein, so the influence of adverse factors will be eliminated, and the sub image including rich information of palm print or palm vein is extracted, which is convenient for the subsequent feature extraction and matching. There are a lot of ROI extraction methods at present [6-9]. The ROI extraction methods of palmprint and palm vein based on the maximum inscribed circle [8] and centroid methods [4] are mainly studied in this paper. The maximum inscribed circle method is that the center and radius would be determined in the palm of the hand, and the largest inscribed circle of all palm area is obtained, then the angle rotation correction of the palm is carried out. After that the maximum inscribed square is cut out in the inscribed circle, which is finally normalized to the size of 128×128 ROI image. The method based on the centroid extraction is that the centroid of the palm image is obtained, and the rectangle sub image which size is 256×256 would be intercepted by using centroid as the center. The experimental results based on PUT vein database [10] and CASIA database [11] show that the method in this paper has good application prospects. In addition, an online simulation system which is easy to use and operate is designed in this paper to obtain the image of palmprint or palm vein and extract ROI in real-time, and it will provide a good research platform for algorithm verification.

II. PRINCIPLES AND METHODS

A. Palm Vein ROI Extraction based on Centroid Method

For a 2D continuous image $f(x,y)$ (≥0), the m_{pq} of $p+q$ moment is defined by (1), the central moment μ_{pq} is defined by (2):

$$m_{pq}=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}x^p y^q f(x,y)dxdy \tag{1}$$

$$\mu_{pq}=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}(x-\bar{x})^p(y-\bar{y})^q f(x,y)dxdy \tag{2}$$

Here p and q are non-negative integers. For the digital image which is discrete and discontinuous, the above formula can be transformed into (3) and (4):

$$m_{pq}=\sum_{j=1}^{N}\sum_{i=1}^{N}i^p j^q f(i,j) \tag{3}$$

$$\mu_{pq}=\sum_{j=1}^{N}\sum_{i=1}^{N}(i-i_c)^p(j-j_c)^q f(i,j) \tag{4}$$

The zeroth and first order moments are as the (5), (6) and (7):

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$$m_{00} = \sum_{j=1}^{N} \sum_{i=1}^{N} f(i, j) \quad (5)$$

$$m_{10} = \sum_{j=1}^{N} \sum_{i=1}^{N} i f(i, j) \quad (6)$$

$$m_{01} = \sum_{j=1}^{N} \sum_{i=1}^{N} j f(i, j) \quad (7)$$

Here i_c, j_c are the coordinates of the centroid, which are defined by (8) and (9):

$$i_c = \frac{m_{10}}{m_{00}} \quad (8)$$

$$j_c = \frac{m_{01}}{m_{00}} \quad (9)$$

We can see that the centroid is the zeroth and first order moments.

In this paper, we use PUT palm vein database [10].The database only has rectangular palm area for the fingers are removed, which will contain abundant information of the palm vein.

The flow chart of ROI extraction of palm vein of this paper is shown in Fig.1:

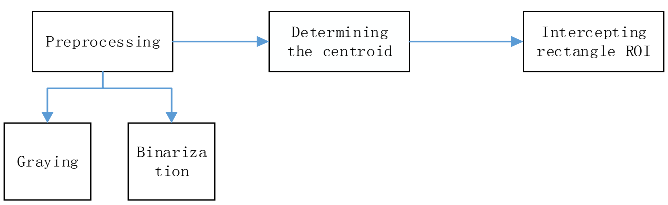

Figure 1. Flow chart of ROI extraction of palm vein (PUT database)

The specific steps of ROI extraction for palm vein are as follows:

1) The original image of palm vein will do the grayscale processing, and it becomes a common gray image as shown in Fig.2.

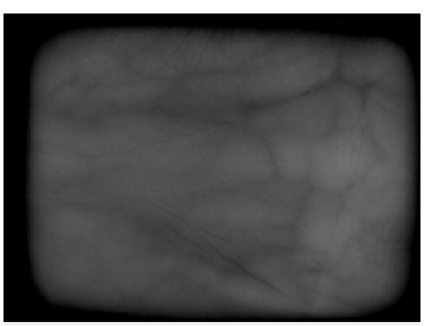

Figure 2. Grayscale image

2) The gray image will do binarization processing, and palm region and the background are separated.

3) Based on centroid algorithm, the centroid of the image is extracted.We take the centroid as the center origin and mark a rectangle which will be intercepted as shown in Fig.3.

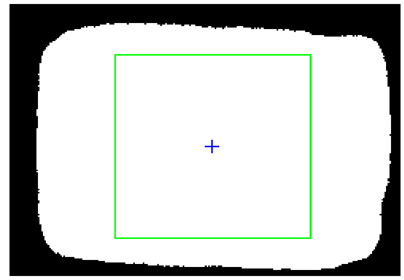

Figure 3. Binary image

4) The 256×256 sub image is cut out in gray image, and so the ROI image of palm vein is obtained, as shown in Fig.4.

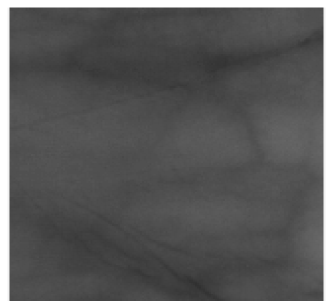

Figure 4. Palm vein ROI

B. ROI Extraction Method based on the Maximum Inscribed Circle

The flow chart is shown in Fig.5.

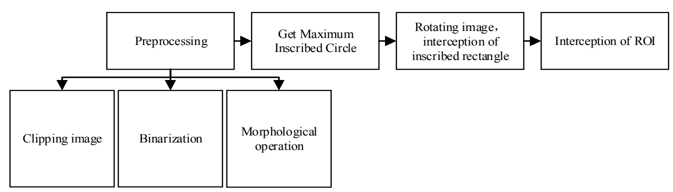

Figure 5. Flow chart of the maximum inscribed circle method ROI extraction

Since there is some noise on the edge of the image, we can cut off some useless edges firstly and then deal with the image binarization processing, make the picture into a black and white image to significantly reduce the calculation cost. After the binarization processing, from the picture we can see that the result is not very ideal, there are some small white spots which are useless noise. We can use the mathematical morphological operation to remove these noise. The palmprint image under a white light source is selected randomly from the CASIA database [11] for example. Fig.6 is the gray image and Fig.7 is the binary image after mathematical morphology operations.

Figure 6. Grayscale image

Figure 7. Binary image after mathematical morphology operations

Because every person has different size of the palm, and the position of the palm is also different when collecting the palmprints, this paper puts forward a locating method based on the maximum inscribed circle. This approach takes advantage of hand shape contour characteristics, specific steps are as follows:

1) After preprocessing we obtain the palm binary image, the center point of the maximum inscribed circle in the palm is located in the palm area. In order to further improve the efficiency of calculations, the center point may fall in the palm around the centroid. We use the centroid as the origin to define a rectangle with a certain length. According to the experience, we ordinarily determine the rectangle sizes as 100×100. Searching the circle center in this area will greatly improve the efficiency.

2) We take a point in the rectangle as the center point of the circle and gradually change the radius of the circle. When the edge of this circle falls on the edge of palmprint, we stop searching radius and record the radius of this circle.

3) We change the center point of the circle and continue searching the radius of the circle. Finally, record the center point and the radius of the biggest circle. This circle is the maximum inscribed circle of the whole palm area.

There is no limit to the rotation position of the palm when collecting the image, so we should do the palm image rotation correction before the interception of ROI.

In addition to the center of O, we should also set a reference point L. We define the maximum inscribed circle radius by R, and make the center of the circle as origin, draw the circle with KR (K>1), the circle will intersect with the fingers. We find the intersection point A, B of the middle finger and the ring finger, and then we get the central point L, connecting OL as the new coordinate *x* axis such as Fig.8. In the new coordinate, the palm image is rotated.

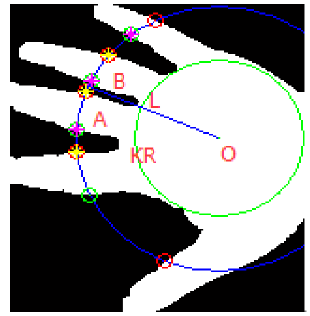

Figure 8. Rotating image

And then, take O as the center point, R as the radius, and take the size of R×R of the non-fixed size sub image. That is in the maximum inscribed circle, we intercept maximum inscribed square as ROI, and then it is normalized to 128×128 size. The following experiments are using palmprint under the white light source as an example, the results are shown in Fig.9 and 10.

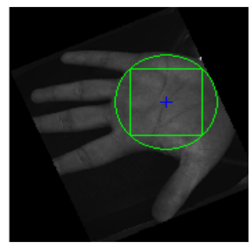

Figure 9. ROI image interception

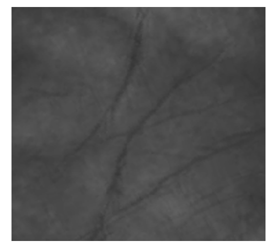

Figure 10. Palmprint ROI

Palm vein images and palmprint images are similar, both of them are from the hand palms, but under the different wavelengths of the light source, the information shown is different. Under the white light source the palmprint information is presented, and under the near infrared light of 850nm, the vein information is represented, so the extraction steps are the same. The final extracted palm vein ROI image is shown in Fig.11. There is rich palm vein information in the image.

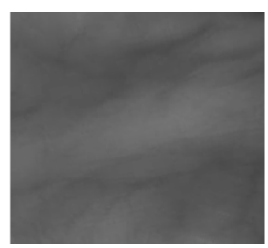

Figure 11. ROI image of palm vein

III. Experiments and Analysis

A. ROI Extraction Experiment of Palmprint and Palm Vein

One hundred images were selected randomly as a test set from PUT palm vein database. In order to obtain more information about palm vein and improve the correct rate of ROI extraction, the size of palm vein ROI was selected as

256×256 according to the characteristics of this database. The experimental results are shown in table 1.

TABLE I. ROI EXTRACTION RESULTS OF PUT DATABASE

Location method	Total images	Correct extraction	Wrong extraction	Accuracy Rate
Centroid extraction	100	99	1	99%

The position of hand is relatively fixed when the images are collected for this database, so the extraction method has better robustness and the rate of correct extraction is high, and there is more information of palm vein near the centroid of palm which is conducive to the subsequent feature extraction and recognition.

Then 100 palm vein images under 850nm wavelength are selected and 100 palmprint images are selected under white LED from CASIA multi-spectral palmprint database, the test method is by maximum inscribed circle, the experimental results is shown in Table 2.

TABLE II. ROI EXTRACTION RESULTS OF CASIA DATABASE

Location type	Total images	Correct extraction	Wrong extraction	Accuracy rate
Palmprint	100	98	2	98%
Palm vein	100	97	3	97%

After analysis we found that the main reason of error locating is that the preprocessing of the image is not very ideal, the background is not pure black, the existence of a large number of white spots lead to program errors in judgment, so the rotation of image fails. In addition, other reasons for this error are that different extension degrees or different rotation rate of palm, making the mistake of positioning when seeking maximum inscribed circle. If it can be further standardized, the correct rate of positioning for palmprint images will be improved.

The test environment of the algorithm in this paper is the PC which has been installed MATLAB software (version number: 2011b), and the CPU frequency is 2.8GHz with 4GB RAM. Comparison of the algorithm running time is shown in Table 3.

TABLE III. COMPARISON OF THE ALGORITHM TIME

Location method	Time (s)
Centroid method	0.2012
Maximum inscribed circle method	0.6563

We can see that the method of maximum inscribed circle is time-consuming, the reasons for this phenomenon is that the algorithm for finding the maximum inscribed circle spends a long time.

B. ROI Extraction Simulation System Based on the Maximum Inscribed Circle

Under the Matlab environment, the real-time image is obtained by the camera. We design a simulation system of online palmprint and palm vein ROI extraction which is based on maximum inscribed circle method. The GUI interface of the simulation system is shown in Fig.12.

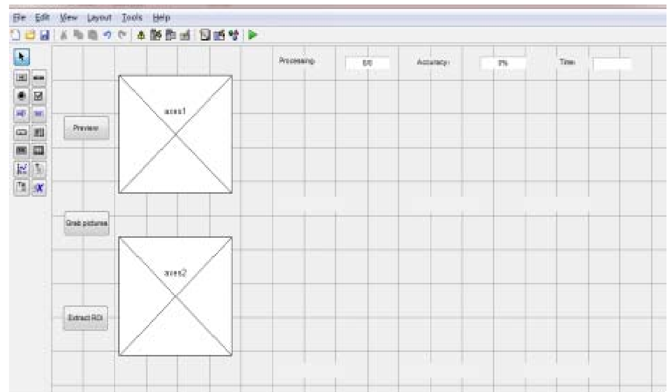

Figure 12. GUI interface

When you click on the “Preview” button, the process of shooting images can be monitored for real-time. When you click on the “Grab picture” button, you can obtain the palmprint image. The button of ROI extraction is to implement the algorithm based on the maximum inscribed circle. Click on this button to start the image preprocessing and ROI extraction. The working flow chart of the simulation system is shown in Fig.13, the experimental results are shown in Fig.14.

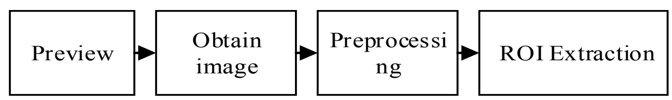

Figure 13. Flow chart of the ROI extraction system

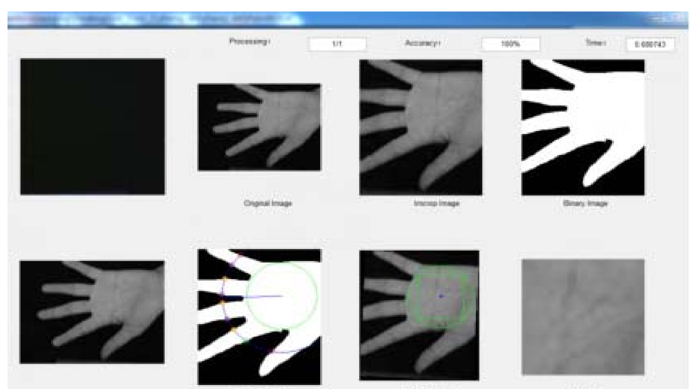

Figure 14. Experimental results of the simulation system

In the above image, we can see that using the method based on maximum inscribed circle can extract ROI correctly, the consuming time only needs about 0.68 seconds.

IV. CONCLUSION

This paper proposed a method based on centroid to obtain the ROI of palm vein from PUT palm vein database, and a method based on maximum inscribed circle to extract the ROI of palmprint and palm vein from CASIA database. The experiment results in two databases show that each method is highly targeted, the robustness is good, and the correct extraction rate is high, which can satisfy the requirement of the experiment. At the same time, this paper designs an online palmprint and palm vein ROI real-time extraction system based on the method of maximum inscribed circle, which has a wide application range and friendly interface. The operation process of this system is simple, which will give a great help for experimental testing and validation. The following work will consider further optimization to improve the processing speed of the maximum inscribed circle algorithm.

ACKNOWLEDGMENT

This work is supported by (1) General Scientific Research Project of Liaoning Provincial Committee of Education (L2014132); (2) Natural Science Foundation of Liaoning Province of China (2015020100).

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