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An Effectual Method for Extraction of ROI of Palmprints

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Abstract—**Extraction of region of interest (ROI) from a palmprint considerably improves the efficiency of identification systems as ROI extracted palmprint images have more entropy and require less processing and storage. In this paper we have extracted the ROI of palmprints of two sets of databases, Hongkong Polytechnic University low resolution palmprint Database and high resolution indigenous database. The method used here employs image processing techniques including dynamic thresholding for binarization, centroid determination, boundary extraction using morphological operations, Euclidean distance calculations from the centroid, valley points determination after smoothening the Euclidean distance plot, from which finally the ROI is extracted.For the above mentioned datasets, the ROI of size 128 X 128 and 256 X 256 respectively have been extracted using this technique.**

Keywords- ROI, boundary extraction, valley points, histogram based dynamic thresholding, euclidean distance, energy thresholding

I. INTRODUCTION

Biometrics is unique behavioral or physiological characteristic of an individual which can be effectively used in identifying him/her. Over the past few years, many types of biometric recognition systems have been developed and implemented using palmprint, fingerprint, iris, retina, speech, signature, hand geometry and DNA. A palmprint consists of many features such as principal lines, ridges, minutiae and delta points. It also consists of many wrinkles whose pattern is well characterized by texture. Palmprint identification can be seen as the capability to uniquely identify a person amongst others, by an appropriate algorithm using the palm features. Palmprints have the critical properties of universality, uniqueness, permanence and collectability for personal authentication. They have several advantages over other biometrics. As compared to fingerprints, palmprints have a larger surface area and contain abundant features. Palms are more robust to damage and dirt; and the line features of a palm are more stable throughout an individual's lifetime. Moreover, faking a palmprint is more difficult than a fingerprint because the palmprint texture is more complicated; and one seldom leaves his/her complete palmprint somewhere unintentionally. The capture device used is less expensive than iris recognition since high – resolution scanners are not required.

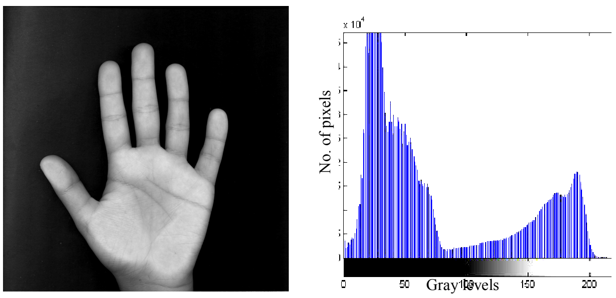
A palmprint biometric system contains different processing stages such as data acquisition, pre-processing, feature extraction and matching. This paper focuses on the pre-processing stage of Region-of- Interest (ROI) extraction of a palmprint which is an essential step in authentication. The scanned palmprint image consists of background and foreground area, where there is practically no information in the background and noise may be inherent in the image. By extracting the ROI, the background is completely removed and noise is reduced, thereby improving the entropy and reducing the size of the image. ROI extracted images lower the computation required for identification since the database size is significantlyreduced.

The advantages of extracting ROI from a palmprint and analyzing it for identification and recognition has resulted in considerable research work in ROI extraction field. Poon et al. have explored the field by locating and segmenting the ROI for palmprint analysis, where the selected region varies with the size of the palm. Instead of square blocks, the region is divided into sectors of elliptical half-rings, which are less affected by misalignment due to rotational error [1]. Kanchana and Balakrishna have explored ROI extraction by region-based segmentation method is attempted to group pixels according to the criterion of homogeneity of regions such as intensity, gray level, colour, textures and shape. The maximum connective texture region is extracted as region of interest which ensures the reliability of the segmentation and provides the ability to resist noise [2]. In [3, 4, 5], J. Doublet et al. proposed a system that uses color informationand neural network model for hand detection; uses shape information and Active Shape Model(ASM) for key points detection. In [6], Ivan Fratric et al. described a real-time model-based hand localization. In [7], Ong et al. designed a touch-less palmprint verification system, which use Gaussian model forhand segmentation and a novel method to find hand key points. In [8], Michal Choras et al. used skin threshold for handsegmentation. Though these approaches [7, 8] are very concise, they may not work in cluster background. In [9], Yufei Han et al. used two parallel placed web cameras for ROI acquisition. In [10] Feng et al. describes development of a real-time ROI acquisition for unsupervised and touch-less palmprint system which will be used in palmprint recognition. The technique uses the concept of probabilities and classifiers. In this paper we have extracted the ROI of palmprint images using dynamic thresholding for binarization, boundary extraction using morphological operations, Euclidean distance calculations from the centroid and valley point determination. Section II explains the procedure of extraction of ROI which is followed by explanation of experimental result obtained on two databases in section III. Section IV concludes the paper.

II. PROCEDURE

A. Palm-Centroid Calculation

The palmprint is binarized using dynamic thresholding of histogram and its centroid is calculated. Histogram of an image, f(x,y) is the probability of existence of grey-levels in the image. A gray-level histogram of an image, f(x,y), which is composed of dark objects in a light background or vice-versa, is given in such a way that object and background pixels have gray levels grouped into two dominant regions. We can extract the object from the background by selecting a threshold 'T' that separates these regions. In case of object being lighter than the background,an object pixel (x,y) is defined for which f(x,y) > T, otherwise, the pixel corresponds to background. Figure 1 shows a palmprint and its corresponding histogram.



(a) (b)

Figure 1. Palmprint and its Histogram

The left dominant region of the histogram corresponds to the background pixels and the right dominant region to the Palm area. The minimum value between the peaks of the two regions is chosen as 'T'. This value may vary with respect to size and illumination and hence binarization of the palmprints is done using dynamic thresholding. Dynamic thresholding helps in minimizing the effects of noise, shadows and severe changes in illumination. Figure 2 shows the binary image of Figure 1(a).

Figure 2. Binarized Palmprint

The centroid of the binarizedpalmprint is calculated by using the equation (1).

$$X_{centroid} = \frac{m_{01}}{m_{11}}, \qquad Y_{centroid} = \frac{m_{10}}{m_{11}} \tag{1}$$

where the momentsm$_{pq}$ are computed by equation (2)

$$m_{pq} = \sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} i^p j^q * f(i,j) \tag{2}$$

The centroid of the palmprint thus obtained is shown in figure 3.

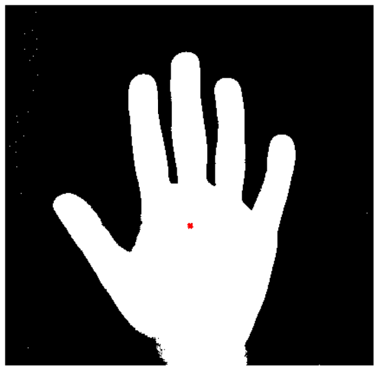


Figure 3. Centroid of Palmprint

B. Boundary Extraction

The boundary B(A) of the palmprint A is given as subtraction of the morphological eroded binary palmprint from the original binary palmprint as defined in equation (3).The erosion of an image A by S is denoted as A S.

$$B(A) = A - (A \ominus S) \tag{3}$$

where S is the structuring element used to erode the palmprint image given by

$$S = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix} \tag{4}$$

The morphological erosion technique helps in getting rid of certain stray pixels from the binary image. This gives better connected boundary as compared to the differential technique, where the boundary of the palmprint is obtained by differentiating the binary image.The extracted boundary of the palmprint is shown in Figure 4.

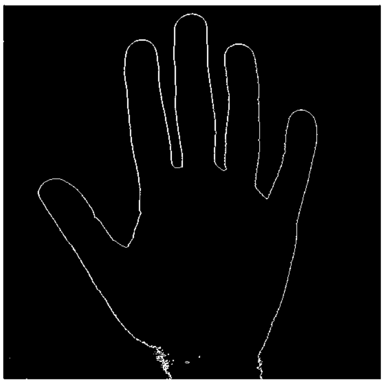


Figure 4. Extracted Boundary of Palmprint

C. Detection of Valley Points

The co-ordinates of the boundary pixels are obtained by tracing the exterior boundaries of objects using eight-point connectivity. The binary image contains certain stray pixels, some of which are removed by morphological erosion. The remaining stray pixels are eliminated by selecting the largest object which is the actual boundary of the palmprint. The boundary pixels of largest object are traced from the left-most pixel. Figure below shows the boundary of the palm extracted with the left-most pixel (Start Co-ordinate).

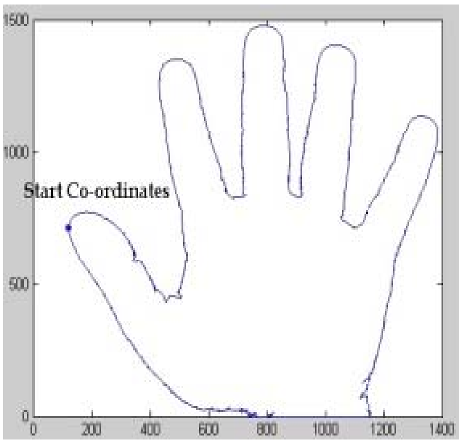


Figure 5. Palmprint Boundary from Start Co-ordinate

The Euclidian Distances (ED) between the centroid ($X_{Centroid}$, $Y_{Centroid}$) and the boundary pixels is computed using equation (5).

$$ED(x, y) = \sqrt{(x - X_{\text{Centroid}})^2 - (y - Y_{\text{Centroid}})^2} \quad (5)$$

The plot of the Euclidian distance between the centroid and the boundary pixel from the start co-ordinates is shown in figure 6.

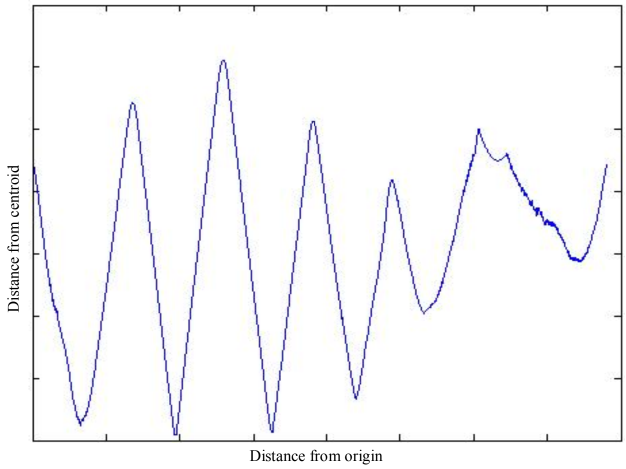
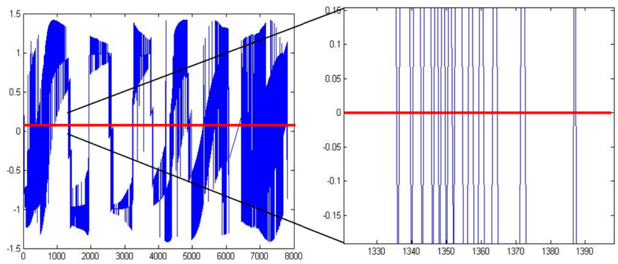


Figure 6. Euclidian Distance plot

The peaks (maximas) and the valleys (minimas) in figure 6 are the finger-tips and the valley-points respectively in Figure 1. The valley points are closer to the centroid, and hence their ED will be minimum. The valley-points in figure 6 are the minima positions of the ED function. To extract these points we first differentiate the ED function and note the zero-crossing points. The differential-graph of a function will reach zero value at both the minima and maxima points of the function. To differentiate between the two, we choose those zero-crossing points, where the differential graph goes from negative value to positive value at point of inflexion.The following figure shows the differential-graph of figure 6.



(a) (b)

Figure 7. (a) Differential-graph of figure 6 (b) Zoomed area of (a)

Here we can see that there are many zero-crossing and points of inflexions which change their sign from negative to positive. This problem arises due to the high frequency components present in ED function. These high frequency components are generated due to the uneven contour of palm. To remove these high frequencies, we degenerate the ED function into its constituent frequencies using Fourier transform and discard the high frequency components and regenerate the same using only low frequencies. The Discrete Fourier transform of the N point Euclidean function is given by

$$F(k) = \sum_{x=0}^{N-1} f(x) * \left(e^{-2\pi j\left(\frac{kx}{N}\right)}\right) \quad (6)$$

where f(x) is the ED function with respect to distance x from starting point and F(k) is its Fourier transform.

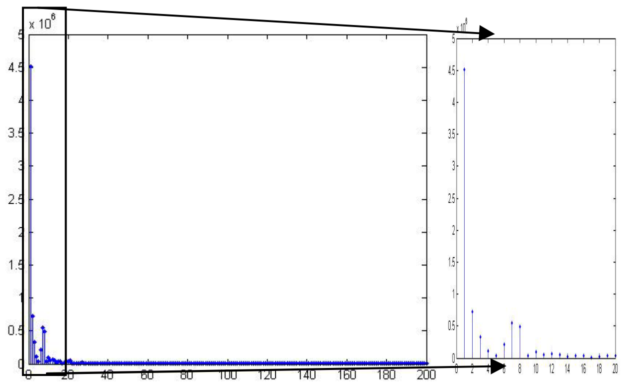


Figure 8. Magnitude plot of frequency distribution of Euclidean function

Figure 8 shows the magnitude plot of Fourier transform of Euclidean function for different frequencies. The graph clearly depicts that the energy of ED function is concentrated in the lower frequency range.

Thus if the ED function is reconstructed considering only low frequency components, it will retain its basic characteristics and thus the position of the valley points will not change. Hence all the high frequency components whose cumulative energy is less than some percentage threshold energy (here we have taken 98% as threshold energy) are removed. The regenerated ED function, its slope and sign of second derivative of ED function is plotted in Figure 9.

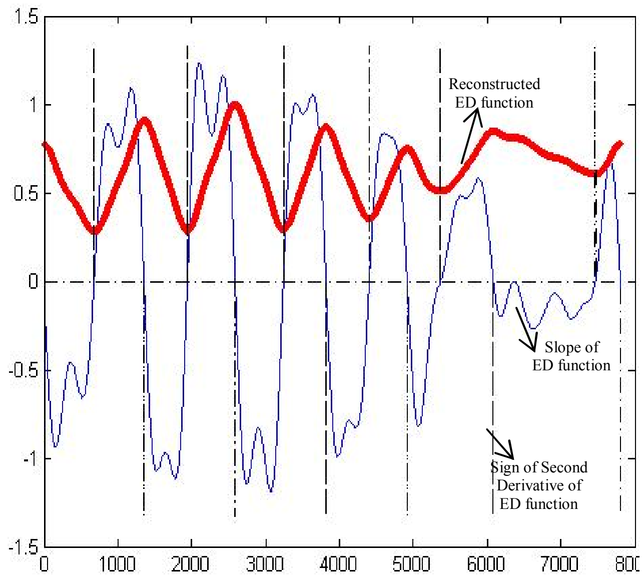


Figure 9. Reconstructed ED function, its slope function and sign of its second derivative

It can be clearly seen in figure 9 that at the minimas (valleys points) of ED function there is a zero-crossing of the first derivative and the sign of its second derivative is positive. Hence the second, third and fourth minimas are obtained as valley points V_1, V_2 and V_3 respectively as shown in figure 10.

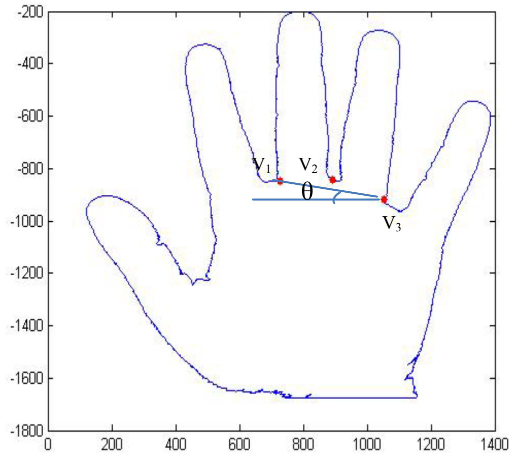


Figure 10. Detected valley Points of a palm

The valley pointsV_1 and V_2 are considered as a reference points to extract the ROI. The line joining the two points may be at an angle θ with the horizontal. The Palm is rotated by angle θ to make the line V_1V_3 horizontal. An ROI of the desired size and shape can then be extracted.

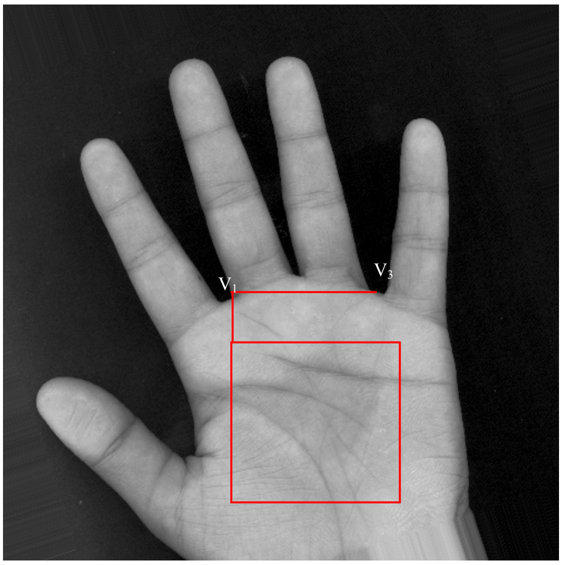


Figure 11. Palmprint is rotated by angle θ to make line V_1V_3 horidontal and then its ROI is extracted

III. DISCUSSION

The technique proposed in above section was implemented on two databases viz. HongKong PolyU 2D palmprint database and a self generated database.

The indigenous high resolution palmprint images were acquired from 65 individuals in vertical position without using pegs. The resolution of the palmprint scans in this database is 1714 X 2464, at 200dpi. The ROI extracted is of size 256 X 256. The size of palmprint is 1.28 GB which reduces to 3.19MB, thus accounting for a reduction factor of 99.75%. The ROI of all the palmprint acquired was effectively extracted.

The HongKong PolyU 2D palmprint database has 2009 palmprint scans from 101 individuals collected in 2 sessions, acquired in horizontal position using pegs. The resolution of the palmprint scans in this database is 384 X 284. The ROI extracted is of size 128 X 128. The size of palmprint is 211MB which reduces to 33.4MB, thus accounting for a reduction factor of 84.17%. The method used to extract the ROI of these palmprints worked very effectively and fast and extracted the correct ROI of all the palmprints in the database. Figure 12 and 13 show the extracted ROI of sample palmprints of both indeginous and Hongkong PolyU databases respectively.

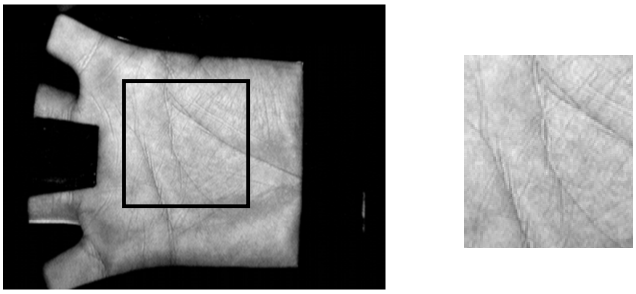


Figure 13. ROI of 128x128 extracted from Palmprint of Hongkong Polyu Database

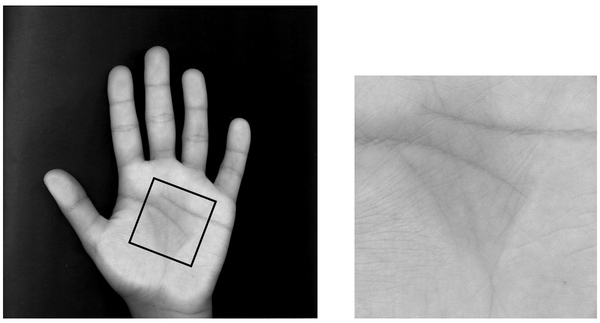


Figure 12. High resolution palmprint and its extracted ROI of size 256x256

IV. CONCLUSION

This paper proposed an effective method of the extraction of ROI of palmprints. The method makes use of both spatial domain techniques like dynamic thresholding, boundary extraction and frequency domain image processing techniques like FFT and energy compaction to make the ROI extraction more accurate. In this paper the proposed method has been employed on various databases with different resolutions to extract ROI of various sizes.

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