

Palm Vein Preprocessing Image based on Homomorphic Filtering

¹Mona A. Ahmed, ²Hala M. Ebied, ³El-Sayed M. El-Horbaty, ⁴Abdel-Badeeh M. Salem

1 Computer Science Department, Faculty of Computer and Information Sciences
Ain Shams University, Cairo, Egypt

2 Scientific Computing Department, Faculty of Computer and Information Sciences
Ain Shams University, Cairo, Egypt

3 Computer Science Department, Faculty of Computer and Information Sciences
Ain Shams University, Cairo, Egypt

4 Computer Science Department, Faculty of Computer and Information Sciences
Ain Shams University, Cairo, Egypt

Abstract

In this paper we propose an image analysis method to extract region of interest (ROI) from palm vein image. After extracting ROI we design a sequence of preprocessing steps to remove the translation and rotation of palm vein images introduced in the data collection process and reduce a lot of data amount without losing much useful information. Then design a sequence of preprocessing steps that enhances the contrast between palm vein patterns and background using Homomorphic filter and Canny filter. The experimental results demonstrate that the recognition rate of our algorithm reaches 99.3% on CASIA Multi-Spectral Palmprint Image Database V1.0 (CASIA database).

Keywords: Biometric, palm vein pattern, ROI extraction, pre-processing image.

1. Introduction

In the ubiquitous network society, in which anyone can easily access information anytime and anywhere, people are also faced with the risk that anyone can easily access information about other people anytime and anywhere. Because of this risk, personal authentication technology which can distinguish between registered legitimate users and imposters is now attracting attention. Password personal identification numbers and cards have been used for personal identification. However, cards can be stolen, and password and numbers can be guessed or forgotten. To solve these problems biometric authentication technology used [1]. Biometrics is automated methods of recognizing a person based on a physiological or behavioral characteristic. An example of or behavioral characteristic are face recognition, fingerprints, hand geometry, signature verification, iris, retinal, finger/hand/palm vein recognition, ear recognition, and voice recognition. Academic and industry tried to develop a device that can catch the vascular patterns under the skin. Fujitsu has developed a palm vein pattern authentication technology that uses vascular patterns as personal identification data [1]. Vein recognition

technology is secure because the authentication data exists inside the body and so it is very difficult to forge [2]. It is highly accurate. This technology has many applications like in banking, hospitals, government offices, in passport issuing, libraries, personal computer, etc. Business growth will be achieved with these solutions by reducing the size of the palm vein sensor and shortening the authentication time [2]. Palm vein authentication has high level of accurate because it is located inside the body and does not change over the life and cannot be stolen. The contactless palm vein authentication technology consists of image sensing and software technology [3]. Palm vein recognition system consists of four key steps: Infrared palm images capture Detection of Region of Interest (ROI) and pre-processing and Palm vein pattern extraction, feature extraction and feature matching [4]. This paper presents an approach to extract region of interest (ROI) and enhancement the palm vein image. The second step enhancement the image by removed illumination and using edge detector to perfectly find the edges of the palm vein. The removed illumination served very efficiently by using homomorphic filtering. Homomorphic filtering is most commonly used for correcting non-uniform illumination in images. The rest of the paper is organized as follows. In Section 2, we introduced the related work and explanation of the general architecture of the palm vein system. The explanation of Dilatation, Erosion and Homomorphic filters is introduces in section 3. Section 4 introduces the details of approach. Section 5 discusses the result of algorithm. Finally, conclusion and discussion are presented in Section 6.

2. Palm vein model and its related work

Extraction of region of interest (ROI) is extract from the original images a specific portion to work with. The ROI extraction has many important advantages. First; it serves as a pre-processing to remove the translation and rotation of palm vein images introduced in the data collection process.

Second, ROI extraction extracts the most informative area in the images. It reduces a lot of data amount without losing much useful information. This will speed up the following feature extraction and matching processes. In the image-based biometric systems, a number of pre-processing tasks are required prior to enhance the image quality, such as: contrast, brightness, edge information, and noise removal, sharpen image, etc. [5] Zhou and Kumar [6] preprocessed the palm-vein images acquired from the completely contactless imaging by normalize it. First segmenting the ROI, the acquired palm images are first binarized so that they able to separate the palm region from the background region. This is followed by the estimation of the distance from center position of the binarized palm to the boundary of palm. After segmentation, the ROI images are scaled to generate a fixed size region. Finally, histogram equalization is employed to obtain the normalized and enhanced palm-vein image. The enhancement has been quite successful in improving the details and contrast of the ROI images. Most of researchers employed this method to find the ROI [7].

Li et al. [8] adopted a 5x5 median filter to remove the speckling noise in the ROI image. Ladoux et.al [9] extracted the region of interest (ROI) and applied 5x5 box filter on the ROI in order to reduce the noise. After then, they corrected the brightness, which is not uniform, by applied a Gaussian low-pass 51x51 filter on the ROI in order to obtain the brightness image which is considered as low frequencies. Then, the brightness is subtracted of the original ROI. At this step, the contrast was still too bad. Therefore they applied a normalization method. In [5] a small area (128*128 pixels) of the palm image capture is located as the region of interest (ROI). After that, noise reduction and contrast enhancement are carried out to produce a better quality of image through the following steps: a. Binarization that transforms the grayscale pattern into a black and white image. b. Skeletonization that reduces the width of lines to one pixel c. Isolated Pixel Removal that eliminates the unwanted isolated points. Palm vein technology works by identifying the vein patterns in an individual's palm. When a user's hand is held over a scanner, a near-infrared light maps the location of the veins. The red blood cells present in the veins absorb the rays and show up on the map as black lines, whereas the remaining hand structure shows up as white. This vein pattern is then verified against a preregistered pattern to authenticate the individual. As veins are internal in the body and have a wealth of differentiating features, attempts to forge an identity are extremely difficult, thereby enabling a high level of security [10]. Figure 1 shows the general processes of the identification model using Palm veins biometrics. After image capture, a small area of a palm image is located as the region of interest (ROI) to extract the features and to compare different palms. Using the features within ROI for recognition can improve the computation efficiency significantly [11].

In the image-based biometric systems there is a number of processing tasks used to produce a better quality of image

that will be used on the later stage as an input image and assuring that relevant information can be detected. Normally, the captured palm vein pattern is grayscale and subject to noise. Noise Reduction and Contrast Enhancement are crucial to ensure the quality of the subsequent steps of feature extraction [11]. Also, the vein pattern extracted from infrared-ray images is represented as dark lines. To extract these lines many researcher used edge detection and morphological operators [3]. Feature extraction plays an important role in palm vein recognition because the performance of feature matching is greatly influenced by its output [3]. Feature matching is achieved by check whether the input image exist in the database to give the permission to that person being authenticated. When one place his/her palm the sensor sense the veins and if they are matched with the registered ones the system allows the person to use it [1]. In our approach we achieve the first three steps of palm vein model uses Homomorphic filter and Canny filter. Figure 1 shows these steps and filters we used.

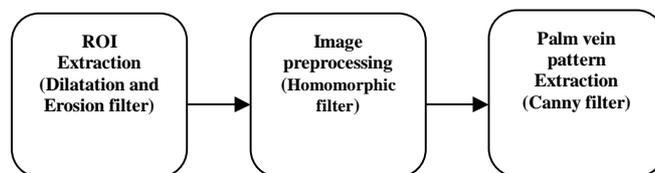


Figure 1 The processes of the identification model using Palm veins biometrics

3. Dilatation, Erosion and Homomorphic filters

Morphological operations are applied on binary images and affecting the form, structure or shape of an object. They are used in pre or post processing (filtering, thinning, and pruning) or used for smoothing, edge detection or extraction of other features. Morphological operations offers a variety of image transformation to eliminate dark (bright) regions from binary images. The two principal morphological operations are dilation and erosion [12]. Dilation allows objects to expand, thus potentially filling in small holes and connecting disjoint objects. Erosion shrinks objects by etching away (eroding) their boundaries. These operations can be customized for an application by the proper selection of the structuring element, which determines exactly how the objects will be dilated or eroded [13].

3.1 The Dilation Filter

The dilation process performed by laying the structuring element SE (matrix consisting of only 0's and 1's that can have any arbitrary shape and size depend on application.) on the image A and sliding it across the image in a manner similar to convolution. The difference is in the operation performed. It is best described in a sequence of steps:

1. If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel.

- If the origin of the structuring element coincides with a 'black' in the image, make black all pixels from the image covered by the structuring element [12].

In another word dilation apply the SE on every pixel (i,j) of image A if at least one pixel of the SE is inside the region then $A[i,j]=1$. Dilation expands the region, smoothes object boundaries and closes holes and gaps.

Notation: $A \oplus SE$. Figure 2 show example of dilation process.



Figure 2 Example of the dilation: a. Original image A; b. The result image: $A \oplus SE$ [14].

3.2 The Erosion Filter

The erosion process is similar to dilation, but we turn pixels to 'white', not 'black'. As before, slide the structuring element across the image and then follow these steps:

- If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel.
- If the origin of the structuring element coincides with a 'black' pixel in the image, and at least one of the 'black' pixels in the structuring element falls over a white pixel in the image, then change the 'black' pixel in the image (corresponding to the position on which the center of the structuring element falls) from 'black' to a 'white'[13].

In another word erosion apply the SE on every pixel (i,j) of image A if the whole SE is included the region then $A[i,j]=1$ otherwise $A[i,j]=0$. Erosion shrinks the object, smoothes object boundaries and removes peninsulas fingers and small objects.

Notation: $A \ominus SE$ [13] Figure 3 show example of erosion process.



Figure 3 Example of the erosion: a. Original image A; b. The result image: $A \ominus SE$.

3.3 Homomorphic filter

Homomorphic filter is a non linear enhancement method. It is simultaneously normalizes the brightness across an image

and increases contrast. The function of homomorphic filter is likely to decrease the low frequency and increase the high frequency. In general, an image can be regarded as a two-dimensional function of the form $I(x, y)$, whose value at spatial coordinates (x, y) is a positive scalar quantity whose physical meaning is determined by the source of the image. In other words, an image is an array of measured light intensities and is a function of the amount of light reflected of the objects in the scene. The intensity is a product of illumination (the amount of source illumination incident on the scene being viewed) and reflectance (the amount of illumination reflected by the objects in the scene). If we denote illumination as $L(x, y)$ and reflectance as $R(x, y)$, then an image $I(x, y)$ can be expressed as [14]:

$$I(x, y) = L(x, y) R(x, y) \quad (1)$$

In this model, the intensity of $L(x, y)$ changes slower than $R(x, y)$. Therefore, $L(x, y)$ is considered to have more low frequency components than $R(x, y)$. Using this fact, homomorphic filtering technique aims to reduce the significance of $L(x, y)$ by reducing the low frequency components of the image. This can be achieved by executing the filtering process in frequency domain. In order to process an image in frequency domain, the images need first to be transformed from spatial domain to frequency domain. This can be done by using transformation functions, such as Fourier transform. However, before the transformation is taking place, logarithm function has been used to change the multiplication operation of $R(x, y)$ with $L(x, y)$ in (1) into addition operation [15].

$$\ln(I(x, y)) = \ln(L(x, y) R(x, y)) \quad (2)$$

$$\ln(I(x, y)) = \ln(L(x, y)) + \ln(R(x, y)) \quad (3)$$

In Homomorphic filtering first transform the multiplicative components to additive components by moving to the log domain. Then use a high-pass filter in the log domain to remove the low-frequency illumination component while preserving the high-frequency reflectance component. The basic steps in homomorphic filtering are shown in figure 4.

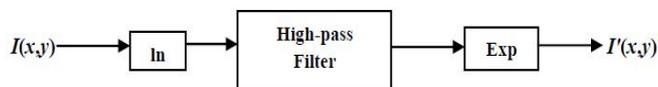


Figure 4 The homomorphic filtering

4. Our Work

Our approach is divided to 3 main steps. First we extract (ROI) from the original images a specific portion to work with using dilatation and erosion filters. Second we applied image enhancement and/or correction using Homomorphic filter. The last step is extraction of palm vein pattern to detect the edges using Canny detector.

4.1 Detection of region of interest (ROI) step

In the first step we have to find the ROI from the image. The following steps are done as show in figure 5 to extract ROI.

1. Convert image to binary
2. Estimates the area of the palm in binary image then apply a 201*201 square mask that could perfectly cover the whole region of palm.
3. After then apply the dilatation filter again to get one point that is the middle point of the hand.
4. Then apply the erosion filter on the same square mask, this time to get exact square placed at same point where the region of interest is placed in actual image
5. Then find xmin, ymin, length, and width of this square to crop ROI from original image.

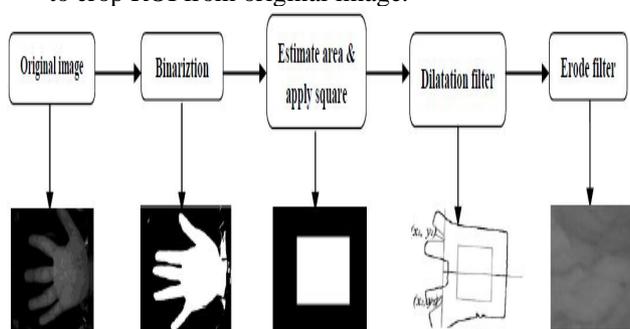


Figure 5 The steps to detect ROI

4.2 Preprocessing step

Homomorphic filtering is a generalized technique for image enhancement and/or correction. It simultaneously normalizes the brightness across an image and increases contrast. The Homomorphic filtering can be summarized in steps show following:

1- An image $I(x, y)$ can be expressed as the product of illumination and reflectance components:

$$I(x, y) = L(x, y) R(x, y) \quad (4)$$

2- Because the Fourier transform of the product of two functions is not separable, we define

$$Z(x, y) = \ln I(x, y) = \ln L(x, y) + \ln R(x, y) \quad (5)$$

Or

$$Z(u, v) = I(u, v) + R(u, v)$$

3- Doing the Fourier transform, as

$$S(u, v) = H(u, v) Z(u, v) = H(u, v) I(u, v) + H(u, v) R(u, v) \quad (7)$$

4- Taking inverse Fourier transform of $S(u, v)$ brings the result back into natural log domain

$$S(x, y) = F^{-1}\{S(u, v)\}$$

$$= F^{-1}\{H(u, v) I(u, v)\} + F^{-1}\{H(u, v) R(u, v)\} \quad (8)$$

5- So the output image can be expressed by the function [16]

$$g(x, y) = e^{S(x, y)} \quad (9)$$

The overall model in block diagram will look as follow: in Fig.6.

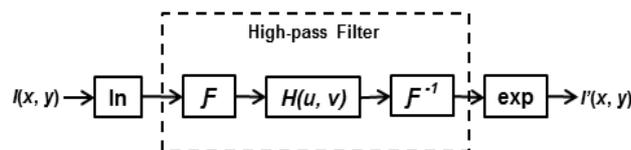


Figure 6 The homomorphic filtering

4.3 Extraction of Palm vein pattern

By using canny edge detector filter can find the edges. The Canny Edge Detector is one of the most commonly used image processing tools, detecting edges in a very robust manner. There are three basic objectives of canny edge detector. The first objective is low error rate: All edges should be found with minimum of spurious responses. The second one is Edge points should be well localized: The distance between one detected point and the true edge point should be minimum. And the last one is Single edge point response: Only one point should be detected for each true edge point [17].

The canny edge detector algorithm runs in 5 separate steps:

1. Smoothing: Blurring of the image to remove noise.
2. Finding gradients: The edges should be marked where the gradients of the image has large magnitudes.
3. Non-maximum suppression: Only local maxima should be marked as edges.
4. Double thresholding: Potential edges are determined by thresholding.
5. Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

5. Results and Discussion

5.1 Database dataset

All the experiments reported in this paper for the palmvein identification CASIA Multi-Spectral Palmprint Image Database V1.0 (CASIA database) [18]. This CASIA database has been acquired using a contactless imaging device and have images from 100 users. Six images were acquired from each user and these images were acquired in two different data acquisition sessions (three images in each session) with a minimum interval of one month. Since our work is focused on palmvein identification and the vascular details are typically observed in the NIR illumination, only the images that were acquired under 850nm and 950nm wavelength illumination from CASIA database were utilized in the following experiments.

5.2 Experimental Results

We evaluate the proposed method using totally 600 infrared palm images in our sample dataset selected randomly from is CASIA Multi-Spectral Palmprint Image Database. The method worked by making subimage which extracted by locating ROI in terms of image registration in database. The vein within ROI is used as biometric features to do

recognition. Removed illumination from image and enhance the image to can easily extract the feature and using it in the next step this enhancement done by making a pre-processing image step. Figure 7 show the result of applied algorithm (a) the original image (b) the result of extract region of interest (ROI) then (c) the result of applied preprocessing step to enhance the image quality.

(a) (b) (c)



Figure 7 Illustration of image enhancement: (a) The original image (b) Extraction of ROI (c) Extraction of Palm vein pattern

6. Conclusion and Future work

We propose a method for palm vein pattern image and processing of an individual. This processed image will be used for future authentication. The proposed method achieves good performance proved by perfectly extract ROI from 594 image from 600 palm vein images used in our experiments with 99.3% correct recognition rate. In particular, this method has many advantages such as it can overcome the problem of rotation and shift and this method is relatively simple and practical.

Our future work is to achieved the feature extraction from the palm vein pattern we extract using many algorithms such as PCA, SIFT and LBP.

References

- [1] Shigeru Sasaki, and Akira Wakabayashi, "Business Expansion of Palm Vein Pattern Authentication Technology", Fujitsu Sci. Tech. J., vol.41,no. 3, pp. 341-347, 2005.
- [2] "Palm Vein Pattern Authentication Technology", Fujitsu white paper, 2005.
- [3] Hao Luo, Fa-Xin Yu, Jeng-Shyang Pan, Shu-Chuan Chu and Pei-Wei Tsai, "A Survey of Vein Recognition Techniques", information technology Journal, vol.9, no. 6, pp.1142-1149, 2010.
- [4] Bhudev Sharma, "Palm Vein Technology", Sardar Vallabhbhai National Institute of Technology, December-2010.
- [5] Debnath Bhattacharyya, Poulami Das, Tai-hoon Kim and Samir Kumar Bandyopadhyay, "Vascular Pattern Analysis towards Pervasive Palm Vein Authentication", Journal of Universal Computer Science, vol. 15, no. 5, pp.1081-1089, 2009.
- [6] Yingbo Zhou and Ajay Kumar, "Human Identification Using Palm-Vein Images", IEEE transactions on information forensics and security, vol. 6, no. 4, pp. 1259-1247, December 2011.
- [7] Y.-B. Zhang, Q. Li, J. You, and P. Bhattacharya, "Palm vein extraction and matching for personal authentication", in Lecture Notes in Computer Science. Springer, pp. 154-164., 2007.
- [8] Qiang Li, Yan'an Zeng, Xiaojun Peng and Kuntao Yang "Curvelet-based palm vein biometric recognition" CHINESE OPTICS LETTERS, vol. 8, no. 6, pp.577-579, June 2010.
- [9] Pierre-Olivier Ladoux, Christophe Rosenberger and Bernadette Dorizzi, "Palm Vein Verification System based on SIFT matching", Third International Conference on Advances in Biometrics, pp. 1290-1298, June 2009.
- [10] Ishani Sarkar, Farkhod Alisherov, Tai-hoon Kim, and Debnath Bhattacharyya, "Palm Vein Authentication System: A Review", International Journal of Control and Automation, vol. 3, no. 1, pp.27-34, March, 2010.
- [11] Hassan Soliman, Abdelnasser Saber Mohamed and Ahmed Atwan, "Feature Level Fusion of Palm Veins and Signature Biometrics", International Journal of Video & Image Processing and Network Security IJVIPNS-IJENS, vol.12, no.1, pp.28-39, 2012.
- [12] Mariusz Jankowski, "Erosion, dilation and related operators", 8th International Mathematica Symposium, pp: 1-10, Avignon, June 2006.
- [13] M. Van Droogenbroeck and M. Buckley, "Morphological erosions and openings: Fast algorithms based on anchors" Journal of Mathematical Imaging and Vision, pp1-35, 2005.
- [14] K. Delac, M. Grgic, T. Kos, "Sub-Image Homomorphic Filtering Technique for Improving Facial Identification under Difficult Illumination Conditions" International Conference on Systems, Signals and Image Processing (IWSSIP'06), pp95-98, September 21-23, 2006.
- [15] Sami Abdulla Mohsen Saleh, and Haidi Ibrahim, "Mathematical Equations for Homomorphic Filtering in Frequency Domain: A Literature Survey", International Conference on Information and Knowledge Management, vol.45, pp.74-77, 2012
- [16] Wenli Liu, Peng He, Hui Li, Hongbo Yu, "Improvement on the Algorithm of Homomorphic Filtering", International Conference on Electrical and Computer Engineering Advances in Biomedical Engineering, vol.11, pp120-124, 2012
- [17] F. Mai, Y. Hung, H. Zhong, and W. Sze, "A hierarchical approach for fast and robust ellipse extraction. Pattern Recognition", The Scientific World Journal, vol. 41, no. 8, pp: 2512-2524, August 2008.
- [18] CASIA MS Palmprint V1 Database [Online]. Available: http://www.cbsr.ia.ac.cn/MS_Palmprint.