Enhancement of Finger Vein and Low Resolution Fingerprint Images for Authentication

[1]Reshma Rajan
Dept. of Electronics and Communication Engineering
TKM Institute of Technology
Kollam,India

[2]Indu M. G
Dept. of Electronics and Communication Engineering
TKM Institute of Technology
Kollam,India

***Abstract*—Biometrics is mainly used for human identification by using different physical traits. The traits that can be used as biometrics are face, palm print, voice, signature, gait etc. But use of these traits in biometrics is not perfectly reliable or secure. So, inorder to overcome the security issue, a non-forgeable pattern has to be used. The finger-vein is a promising biometric pattern for personal identification in terms of its security and convenience. The fingerprints are also unique like finger-vein pattern. So it can be used along with finger-vein as biometric trait. In this paper, the images are enhanced by incorporating the concept of local histogram equalization, which improves the local contrast of an image.**

Index Terms— Image preprocessing; Morphological operation; Image enhancement; Local histogram equalization.

I. INTRODUCTION

Personal identification technology is becoming more important in security systems. Traditionally, the authentication modes such as key, passwords or Personal Identification Numbers (PINs) are easy to implement but are vulnerable to the risk of exposure and being forgotten. Biometrics, which authenticates and determines an individual's identity by utilizing the uniqueness of his or her biological and behavioural characteristics and is becoming one of the most popular and promising alternatives to the traditional password or PIN based authentication techniques. The tremendous growth in the demand for more user-friendly and secure biometrics systems has motivated researchers to explore new biometrics features and traits.

There are two types of biometric based systems-unimodal biometric based system and multimodal biometric based system. Unimodal biometric-based systems have demonstrated that using a single biometric source for personal identification. A multimodal biometric system usually contains two or more biometric sources and merges them together for personal identification. Hence, compared to unimodal biometric approaches, multimodal biometric approaches always behave better in universality, accuracy and security. The anatomy of human fingers is quite complicated and largely responsible for the individuality of fingerprints and finger veins.

The advantages of these two patterns are:
(i) The fingerprint and vein are carried by one finger and both have reliable properties in biometrics.
(ii) Live body identification: Finger-vein image can be taken from live body.
(iii) High security: The vein pattern is an internal feature and difficult to forge.

Pre-processing is a common name for operations with images at the lowest level of abstraction -- both input and output are intensity images. The aim of pre-processing is to improve the image data and enhances some image features important for further processing. The image enhancement is the process of making images more useful. The reasons for doing this include: highlighting interesting detail in images, removing noise from images and making images more visually appealing.

Image enhancement techniques can be divided into two broad categories:
1. Spatial domain methods, which operate directly on pixels, and
2. Frequency domain methods, which operate on the Fourier transform or wavelet transform of an image.

A. Related Works

Personal identification using finger vein and fingerprint patterns has invited lot of research interest. M. Kono *et al.* proposed that biometric identification from finger vein patterns can be done using normalized cross correlation of finger vein images [2]. Miura *et al.* [3] have further improved the performance for the finger vein identification using a repeated line tracking algorithm. The robustness in the extraction of finger vein patterns can be significantly improved with the use of local maximum curvature across the vein images and is detailed in [4]. Kejun Wang *et al.* proposed another method for matching finger vein images using relative distance and angles [5]. G.Ramaswamy *et al.* [10] proposed a method for fingerprint recognition using minutiae features.

In this paper, finger vein and low resolution fingerprint images are enhanced for authentication purpose. The finger images are preprocessed to improve the image data which suppresses undesired distortions and enhances some image features relevant for further processing task.

This paper is organized as follows. In section II, proposed method of finger-vein image preprocessing is discussed, which include segmentation of ROI and image enhancement. The preprocessing steps for the fingerprint images are detailed in Section III. Section IV compliments the results with discussion. The key conclusions from this paper are summarized in section V.

II. PROPOSED METHOD OF FINGER-VEIN IMAGE PREPROCESSING

The preprocessing steps (see Fig. 1) are applied on finger vein images that include: segmentation of ROI and image enhancement to extract stable or reliable vascular patterns.

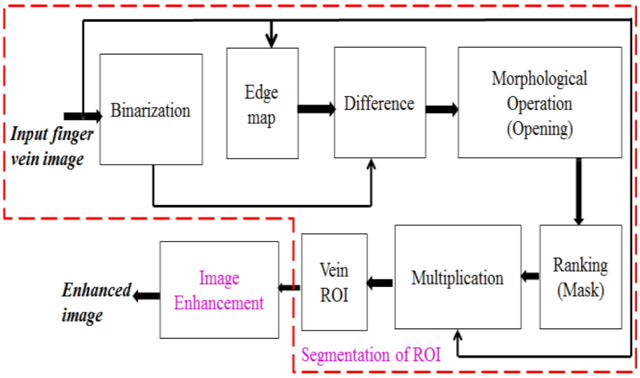
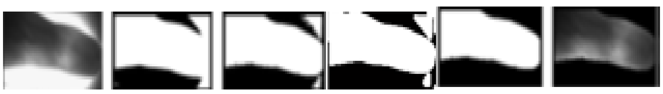


Fig. 1. Block diagram of finger vein image preprocessing.

A. Segmentation of ROI

Each of the finger-vein images is first employed to binarization, using a fixed threshold value, to coarsely localize the finger shape in the images. Some portions of background still appear as connected to the bright finger regions, predominantly due to uneven illumination. The unwanted connected regions in the binarized images are eliminated in two steps: First, the Sobel edge detector is applied to the entire image, and the resulting edge map is subtracted from the binarized image. Then applying morphological operation called opening. But the image contain extra bounded regions other than the required region.These bounded regions are labeled in the image. By applying histogram, the largest bounded object in the image was extracted that resembles to ROI mask. The resulting binary ROI mask is used to segment the ROI from the original finger-vein image. Fig. 2. shows image samples from preprocessing steps that ensures reliable segmentation of ROI.



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

Fig. 2. Extraction of ROI from finger vein images. (a) Input image sample. (b) Binarized image. (c) Edge map subtracted from (b). (d) Image after applying morphological operation. (e) ROI mask from the image in (d) and the ROI finger vein image.

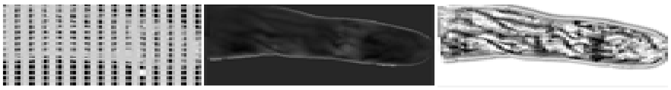
B. Image Enhancement

The finger-vein details in the images, particularly the thin ones, are not very clear. This can be attributed to the uneven illumination and imperfect placement of fingers during the imaging. Therefore, the vein images with low contrast and uneven illumination are subjected to image enhancement. The acquired images are first divided into overlapping 30 × 30 pixels subblocks, and the average gray level in each of the blocks is computed. This average gray level is then used to construct average background image. Thus, direct partitioning of images into subblocks results in the biased estimation of background illumination. Therefore, the average gray level, G of each subblocks is computed as follows:

$$G = \begin{cases} \dfrac{\sum_{\forall(x,y)\in D} D(x,y)}{\|M\|} & \|M\| > 0 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

$$M = \{\forall(x,y) \in D, D(x,y) \neq S_{bg}\} \quad (2)$$

where D is the image subblock, M is the subset of D that contains all the foreground pixels, i.e., those pixels whose values are not equal to the filled/fixed background pixel value, S_{bg} represents the background pixel intensity values, and $\| \|$ represents the cardinality operator that yields number of elements inside. The resulting image is then subjected to the local histogram equalization to obtain the final enhanced vein image as shown in Fig. 3.



(a) (b) (c)

Fig. 3. Image enhancement. (a) Image subblock. (b) Background estimated finger vein image. (c) Image after local histogram equalization.

III. PROPOSED METHOD OF FINGERPRINT IMAGE PREPROCESSING

The fingerprint image (580 × 381 pixels) is employed for the preprocessing, as shown in Fig. 4. and explained in the following section.

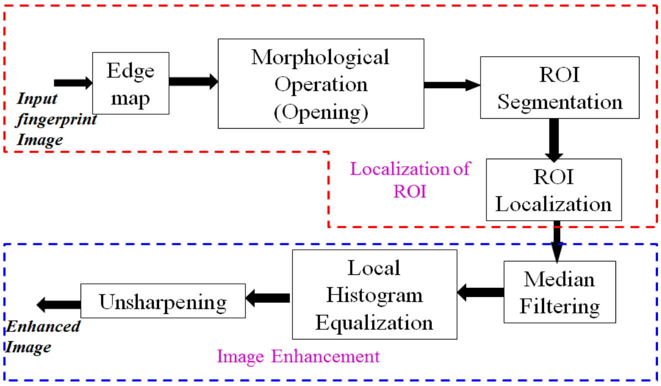


Fig. 4. Block Diagram of fingerprint image preprocessing

A. Localization

A Sobel edge detector is first used to obtain the edge map and localize the finger boundaries. The resulting image is shown in Fig. 5. This edge map also illustrates isolated noise and is eliminated by morphological operation called opening. The ROI can be estimated by using this resulting mask. Then locate the required region from the ROI fingerprint image and is used as the fingerprint image for the identification.

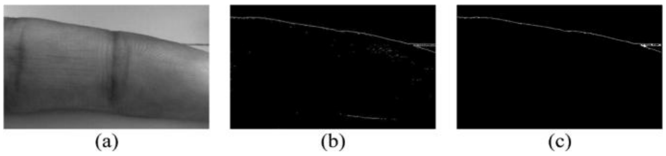


Fig. 5. Localization of finger texture regions. (a) Input image. (b) edge map. (c) Image after opening.

B. Image Enhancement

The finger texture image is first subjected to median filtering to eliminate the impulsive noise. The resulting images have low contrast and uneven illumination. Therefore, the background illumination image was first obtained from the average of pixels in 10 × 10 pixel image subblocks. The resulting image is subtracted from the median-filtered finger texture image and then subjected to local histogram equalization. It can be shown in Fig. 6.

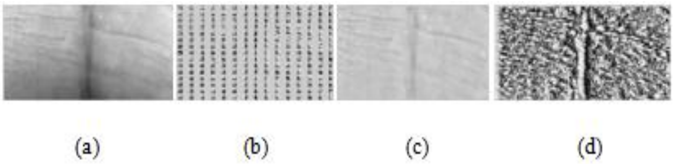


Fig. 6. Fingerprint image enhancement. (a) Median-filtered fingeprint image. (b) Overlapping subblocks of localized ROI fingerprint image. (c) Image after removing uneven illumination. (d) Image after local histogram equalization.

IV. RESULTS AND DISCUSSION

In this project, the preprocessing steps including enhancement of finger vein and fingerprint images have been completed. Simulation is done in MATLAB R2010a. The database used is "The Hong Kong Polytechnic University Finger Image Database (Version 1.0)".

A. Finger-vein Image Preprocessing

The input finger-vein image (513 x 256) was given for preprocessing steps. In preprocessing, the first step was the Region of Interest (ROI) extraction. The ROI or the object part (i.e. the finger portion in the input image) has to be separated from its background. The input image was subjected to binarization by selecting a threshold. . Here, the selected threshold value is 230.The binarized image was applied for background separation which facilitates ROI extraction. The next step of ROI extraction was edge detection. A Sobel edge detector was used to find the edges from the input grayscale finger vein image. The Sobel operator performs a 2-D spatial gradient measurement on an image which emphasizes regions of high spatial frequency that correspond to edges. Here, edge of the object was mapped because the edge map has to be subtracted from the binarized image for obtaining the mask for ROI extraction. The mask was used to extract the required region (ROI) from an image correctly. But the mask obtained after this processing was not accurate since it contains so many connected white pixels other than ROI region. So these connected white pixels other than the ROI region was eliminated by applying morphological operation called opening. Opening can be used to eliminate all pixels in regions that are too small to contain the structuring element. Here, the structuring element was "disk", since the finger portions in the image have curved regions. The resulting image contains four bounded white regions. These bounded regions were labeled as '1', '2', '3' and '4'. Based on these labels, a histogram was generated and an analysis was carried out. On the basis of this analysis, the largest connected object in the image was figured out. This largest connected object accurately represented the ROI extracted mask and was used to segment the ROI from the input finger vein image. This mask was multiplied with the input grayscale image to obtain the ROI finger vein image. Now, the ROI of the finger vein image has been extracted and was used for further processing. The next step of image preprocessing is image enhancement. i.e., the image is enhanced for better visualization. For that, the background of the vein structure was estimated. For background estimation, the resulting image was divided into overlapping 30 × 30 pixels subblocks. Here, the overlapping subblocks were considered for preserving the continuity of vein structure. The resulting image contains 255 overlapping subblocks, each containing 30 x 30 pixels. Then the average gray level of each block was computed for background estimation and was resized for subtracting from ROI vein image. The resized average graylevel image was subtracted from the ROI vein image. The resulting image was then subjected to local histogram equalization for obtaining the final enhanced vein image. Histogram equalization is used for enhancing the contrasts in an intensity image. In order to do local histogram equalization, a mask size (10 × 20) was selected, which describes the size of the portion of the image to equalize at a time. The selected mask was placed above the image and then probability density of each value inside the mask was calculated. The cumulative distribution of each value was also computed. Then the centre pixel value of the overlapping mask area was replaced by its Cumulative Distributive Function (CDF). Similarly, the computation was done for whole matrix by moving the mask. As the result, the finally obtained image was a locally enhanced one.

B. Fingerprint Image Preprocessing

The fingerprint images of size 580 x 381 are available in the database. In fingerprint preprocessing stage, the first step is image localization. The image localization means that the required region is located accurately for further processing task. For that, the first step is to find the edge map of input fingerprint image. A Sobel edge detector was used to obtain the edge map of an image because it detects edges along with their orientation. This edge map was used to extract required region of an image. But the edge map image contains connected white pixels other than ROI edge. These edges can be eliminated by applying morphological operation called opening. Now, the resulting image contains only ROI edge. So, it was used to extract the region of interest from the input fingerprint image and the required portion was cropped from ROI. During imaging, the finger surface might contain impurities like dust, oil etc. which will cause noises in the acquired image. These noises were removed from the image by applying median filter and smoothened image was obtained. The median filtering was carried out on the given image pixel by pixel replacing each pixel with the median of neighbouring pixel. The next step of fingerprint image preprocessing was image enhancement. For that, the resulting image was first divided into overlapping 10 × 10 pixels subblocks. Here, overlapping subblocks were considered since overlapping blocks could preserve continuity of fingerprints. The resulting image contains 255 overlapping subblocks, each subblock containing 10 x 10 pixels. Then the average gray level of each block was computed for removing uneven illumination and is resized. The resulting image was subtracted from the median-filtered fingerprint image and was then subjected to local histogram equalization. By applying local histogram equalization, the images were enhanced locally by a selected mask of size 10 × 20.

V. CONCLUSION

Biometrics authenticates and determines an individual's identity by utilizing the uniqueness of his or her biological and behavioural characteristics. There are two types of biometric based authentication systems, unimodal biometric-based systems and multimodal biometric-based systems. The unimodal biometric-based systems use single biometric source for authentication purpose. A multimodal biometric system contains two or more biometric sources and merges them together for personal identification. Compared to unimodal biometric approaches, multimodal biometric approaches always behave better in accuracy and security. So, here two biometric patterns are considered. i.e., finger vein and fingerprint patterns. In this project the images were preprocessed for further processing task, which includes segmentation of ROI and image enhancement. Using binarization and edge detection techniques, binary mask was obtained and it was used to segment the ROI from the input images. Then, the images were enhanced for better visualization using local histogram equalization.

REFERENCES

[1] Ajay Kumar and Yingbo Zhou, "Human identification using finger images," *IEEE Transactions on Image Processing*, vol. 21, no. 4, pp. 2228-2244, April 2012.

[2] M. Kono, H. Ueki, and S. Umemura, "Near-infrared finger vein patterns for personal identification," *Applied Optics*, vol.41, no. 35, pp.7429–7436, December 2002.

[3] N. Miura,A. Nagasaka, and T. Miyatake, "Feature extraction of fingervein patterns based on repeated line tracking and its application to personal identification," *Machine Vision and Applications*, vol. 15, no. 4, pp. 194–203, October 2004.

[4] N. Miura, A. Nagasaka, and T. Miyatake, "Extraction of finger-vein patterns using maximum curvature points in image profiles," in *Proceedings of IAPR Conference Machine Vision Applications*, Tsukuba Science City, Japan, May 2005, pp. 347–350.

[5] Kejun Wang, Hui Ma, Oluwatoyin P. Popoola and Jingyu Li, "Finger vein recognition," 2010.

[6] Mohit Soni, Sandesh Gupta, M.S.Rao, Phalguni Gupta, "A New Vein Pattern-based Verification System,"*International Journal of Computer Science and Information Security*, vol. 8, no.1, 2010.

[7] Yongming Yang, Kunming Lin, Fengling Han, Zulong Zhang, "Dynamic Weighting for Effective Fusion of Fingerprint and Finger Vein," 2012.

[8] Zhi Liu and Shangling Song, "An Embedded Real-Time Finger-Vein Recognition System for Mobile Devices," *IEEE Transactions on Consumer Electronics*, vol. 58, no. 2, pp. 522-527, May 2012.

[9] Raju Rajkumar, K.Hemachandran "A review on Image enhancement of fingerprint using Directional filters," *Assam University Journal of Science & Technology*, vol 7, no.2, pp. 52-57, 2011.

[10] G.Ramaswamy, Vuda Sreenivasarao, P.Ramesh, D.Ravi Kiran, "A Novel Approach for Human Identification through Fingerprints," *International Journal of Computer Applications*, pp.0975- 8887, vol. 4, no.3, July 2010.

[11] L. Wang, G. Leedham, and S.Y Cho, "Minutiae feature analysis for infrared hand vein pattern biometrics," *Pattern Recognition*, vol. 41, no.3, pp. 920-929, March 2008