Fingerprint Image Enhancement using Morphological Transform

K. V. Kale
Dept. of Computer Science &IT,
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (MS)-431004 India
+91-240-2400431 ext 461, 534
kvkale91@rediffmail.com

R. R. Manza
Dept. of Computer Science &IT
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (MS)-431004 India
+91-240-2400431 ext 461
ramesh_manza@yahoo.com

V. T. Humbe
Dept. of Computer Science &IT
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad -431004 India
+91-240-2400431 ext 461
vikashumbe@yahoo.co.in

Prapti Deshmukh
Dept. of Computer Science &IT,
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (MS)-431004 India
+91-240-2400431 ext 461
praptiv@rediffmail.com

Abstract:
The performance of recognition system is highly depends on the quality of fingerprint. A fingerprint image may not always be well defined due to elements of noise that corrupts the clarity of the ridge structures or basic information, which is required for recognition. Noise may occur due to variations in skin and impression condition. Thus, image enhancement techniques are often used to reduce the noise and enhance the structure of ridges and valleys for minutiae detection. In this paper, we propose a morphological transformation approach for fingerprint image enhancement. In this work first we have applied the spatial domain operations for contrast enhancement and gaussian linear spatial filtering by using the convolution and correlation operation for remove noise. Secondly we applied the Morphological-structuring element by opening and top-hat transform to link disconnected ridges. These set of operations are applied on authenticate fingerprint database (FVC2002) and we achieve the better fingerprint image enhancement in terms of connecting the broken ridges which can reduce the False Accept Rate (FAR).

Keywords: Contrast enhancement, Linear spatial filtering, Morphology, dilation, erosion top-hat transform, structuring element.

1. Introduction:

Fingerprint enhancement is an important step in fingerprint recognition system. The quality of ridge structures in a fingerprint is an important characteristic required for minutiae detection. The performance of fingerprint recognition system is depends on the quality of fingerprint image [1] [2]. Therefore, most of the efforts required for improving the quality of fingerprint image. This is most difficult task because fingerprint images consist of noises. Noise gets generated due to acquisition, scanning and inadequate information of fingerprint image. Live scan method provides better images does not need expertise, but highly distorted images are still possible because dryness of skin, skin disease, sweat, dirt or humidity, different downward pressure on the surface, contrast difference, partial description of whole fingerprint, non-uniform pressure and so on provides the corrupted or noisy images [3]. A typical biometric recognition system having two types of errors: 1) False Acceptance Rate (FAR): Which is mistaking measurement of two different fingers to be form same finger. 2) False Reject Rate (FRR): Which mistaking two measurements from same finger to be form two different finger [2] [4]. Most of recognition system the two prominent feature i.e. ridge ending and ridge bifurcation. Minutiae extractions are the basic pre-requisite for feature extraction in fingerprint atomization system. In all previous reported work researchers, designer had applied their sincere efforts to suggest the strategies and develop new techniques in fingerprint enhancement through segmentation, normalization, orientation estimation, filtering, binarization, thinning etc. These technique having different approach and directions to calibrate their performance and maintain the sequence as per the problem requirement under fingerprint enhancement. But in most of the cases a fingerprint image contains region of good, medium and poor quality, where the ridge pattern and valley are very noisy and corrupted due to the various reasons as specified above. Such type of image found to be more difficult for ridge and minutiae extraction. In order to improve the good performance of these extraction algorithms in poor quality fingerprint images, there is a need of an enhancement algorithm to improve the image quality for genuine minutiae extraction. The overall objective of the fingerprint image enhancement is to improve the ridge and valley structure for genuine feature extraction. The paper organized as follows. In section 2 describe the proposed fingerprint image enhancement algorithm. In section 3 gives the details of the experimental result and finally in section 4 gives the conclusion.

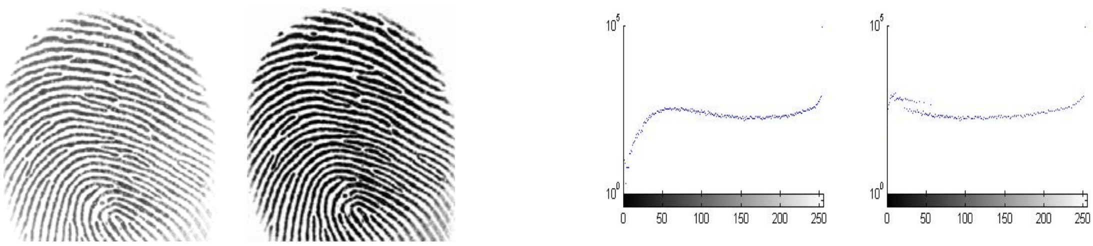
2. Fingerprint Image Enhancement:

One of the mostly used technique for fingerprint enhancement using gradient based on Directional field calculation or Orientation field estimation [1]. The Jie Zhou et al propose the model-based technique for computation of orientation field of fingerprint images [5]. But sometimes the ridge orientation computation gives unsatisfactory results especially on poor quality images. Some of the techniques based on the direct-gray scale enhancement [6] by using the spatial and frequency domain approach for fingerprint noise removal. In this paper we are focusing the morphological dilation and erosion operation on gray-scale fingerprint image for improving the ridge structure of fingerprint image that is required for genuine feature extraction. In our experiment, first we increase the contrast of the given fingerprint image then apply the linear spatial filtering using convolution and correlation operation. And finally apply the morphological operations as shown in figure 1.

2.1 Contrast Enhancement:

Contrast enhancement is stretching the intensity level also known as contrast stretching transformation. Low contrast fingerprint images can result from poor illustration, lack of dynamic range in image acquition, dryness of skin, sweet, wrong setting of acquition device etc. The contrast enhancement is increasing the dynamic range of the gray levels in the fingerprint image for further processing. In contrast enhancement the *gamma* operator maps the intensity values of fingerprint image. If the *gamma* is less than 1 the mapping is weighted towards higher and if *gamma* is greater than 1 the mapping is weighted towards lower output values. In this paper we are using the *gamma operator* is equal to 2. Contrast enhancement does not affect on the original structure of the fingerprint image as shown in figure 2.

Figure 1: Block diagram of Fingerprint Image Enhancement



(a) (b) (c)

Figure 2: (a) Original Image (b) contrast enhancement (c) histogram of (a) and (b)

2.2 Linear spatial filtering:

In the, linear operation multiplying each pixel in the neighborhood by a corresponding coefficient and summing the results to obtain the response at each point *(x,y)*. If the neighborhood is of size M-by-N, MN coefficients are required. The coefficients are arranged as matrix called *kernel* or *mask*. In this paper we used the correlation and convolution operation as a *mask* for fingerprint filtering. Correlation is a process of neighborhood operation in which each output pixel is a weighted sum of neighboring input pixels. The weights are defined by the correlation *kernel* or *mask*. The convolution is same process, except that the *mask* or *kernel* is rotated by 180^0 before passing for filtering. Linear filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by gaussian using correlation and convolution operator to compute the values of the pixels in the neighborhood of the corresponding input pixel of fingerprint image. Linear filtering of image I of size M-by-N with the filter kernel *w* of size m-by-n can define as follows [7]:

$$f(x,y) = \sum_{s=-(m-1)/2}^{(m-1)/2} \sum_{t=-(n-1)/2}^{(n-1)/2} w(s,t)\, f(x+s, y+t) \quad ..(I)$$

Where, x=0,1,2,…….M-1, and y=0,1,2,…….N-1. Here we have show the gaussian mask , which is applied on fingerprint images as shown in figure 3.

0.0113	0.0838	0.0113
0.0838	0.6193	0.0838
0.0113	0.0838	0.0113

(a)

0.0001	0.0044	0.0044	0.0001
0.0044	0.2411	0.2411	0.0044
0.0044	0.2411	0.2411	0.0044
0.0001	0.0044	0.0044	0.0001

(b)

Figure3: Gaussian filter mask of a) 3-by-3 and b) 4-by-4 when standard deviation sigma =0.5

2.3 Morphological Approach

Morphology is a biological term that deals with the structure and shapes that's why we found more suitable for the fingerprint image enhancement. Morphology offers a unified and powerful approach to numerous enhancement of fingerprint structure. When we perform the morphological operation like dilation and erosion, the *structuring element* plays an important role. Mathematical morphology is a comparing the objects contained in an image with known object called *structuring element (SE)* [8] [9]. In fingerprint image enhancement the dilation (⊕) and erosion (⊖) are used most often in combination using the same or different structuring element. In this paper we have used the morphological opening, which is, defines as A o B is simply erosion of A by B followed by dilation of the result by B [7].

$$\mathbf{A \circ B = (A \ominus B) \oplus B} \ldots\ldots\ldots..(II)$$

When we subtract the opened image from the original image is known as *top-hat Transform (T)* is defined as follows:

$$\boldsymbol{T = I - (I \circ SE)} \ldots\ldots\ldots\ldots\ldots..(III)$$

Where, *I* is the linear filtered fingerprint image, *SE* is the structuring element. This transform is useful for enhancing details in the presence of the ridge structure as shown in figure 4.

3. Experimental Results:

In our experimental work we have applied a specified set of operation or algorithm on the various fingerprint images of size 374-by-388, which are collected from FVC2002 database. The images of varying quality are used to evaluate the performance of our algorithm. In first step we do experiments for contrast enhancement of fingerprint images by using the intensity stretching technique using *gamma operator*. In this step we used the *gamma* is equal to 2. In second step we apply the Linear Spatial filtering using the convolution and correlation operation using gaussian mask. By using linear filtering we remove the noise of the fingerprint image. And finally we applied the morphological approach for ridge linking of the broken ridges. The combination of dilation and erosion morphological operations i.e. top-hat transform gives the satisfactory result. The typical result of morphological transform (top-hat) is shown in figure 4. Broken ridges gaps of figure 4 and 5 (a), (c) are shown in rectangle. The resultant connected ridges are shown in corresponding rectangle of figure 4 and 5 (b) (d). This algorithm fails when the ridges are highly corrupted or noisy as shown in figure 4 and 5 (f) and (h). Somewhat similar type of work done by Moler E [8] [10] but our algorithm gives the satisfactory result. In this algorithm we have used the 'disk' shaped structuring element *(SE)* of length 5. All these set of operations are applied on the gray-scale image and our output fingerprint image is also a gray-scale image.

4. Conclusion:

In this work we have describe our algorithm of fingerprint image enhancement. Where as original images rely on quantities measurement of inspection, but they can provide a natural representation of fingerprint imperfections such as noise and broken ridges. The experimental result shows that, this algorithm can effectively increase the contrast, reduce the noise and morphological transform (top-hat) is used to connect or fill the gaps between the broken ridges. It is necessary to choose the appropriate *structuring element* as per the problem requirement. The gap between the ridges can remove two false ridge ending minutiae which will help to reduce the false accept rate (FAR). The resultant image of this algorithm can be directly used to extract the genuine features. The results of this algorithm can be further extends to convert resultant image into binary image. But to convert image into binary form the appropriate threshold value must be select to avoid image losses. This algorithm may fail for heavy noisy fingerprint images.

Acknowledgement:

This research work is supported by University Grant commission, New Delhi, India. (F. 14-14/2003(SR)).

5. Reference:

[1] Ling Hong, Yifei Wan, A.K. Jain, "Fingerprint Image Enhancement: Algorithm and Performance Evaluation", IEEE, Tran. On Pattern Analysis and Machine Intelligence, vol. 20. pp. 777-789, Aug-1998.

[2] D. Maltoni, Dmaio, A.K. Jain, S. prabhakar, "Hand book of Fingerprint Recognition", springer, 2003.

[3] L.C. Jain, U. Halici, I.Hayashi, S.B. Lee, S. Tsutsui, "Intelligent Biometric Techniques in Fingerprint and Face Recognition", by CRC Press LLC,1999.

[4] Sharath Pankanti, Salil Prabhakar, A. K. Jain," On the individuality of fingerprints", Proc of IEEE computer society conf. on Computer Vision and Pattern Recognition (CVPR) pp.805-812, Dec-2001.

[5] Jie Zhou, and Jinwei Gu, "A Model-based method for the computation of fingerprints orientation field" IEEE Tran. On Image Processing Vol. 13 No. 6 June 2004.

[6] Maio.D. maltioni D, "Direct grayscale minutiae detection in fingerprints" IEEE Tran. On Pattern analysis & machine Intelligence Vol. 19(1), pp-27-40, 1997.

[7] R. C. Gonzalez and R. E. Woods, "Digital Image Processing", Second Edition, Pearson education Pvt. Ltd., 2003.

[8] Moler E , Blotta E, Pastore J, Meschino G, Ballarin V, "Enhancement techniques in fingerprint as a tool in Dactyloscopy", JCS&T, Vol.3 No.2 PP.52-55, 2003.

[9] J. Serra, "Image Analysis and Mathematical Morphology", Vol. I London Academic Press. 1982.

[10] Marcelo De Almeida Oliveira and et al, "Reconnection of fingerprint Ridges based on Morphological Operators and multi-scale Directional information", IEEE proceedings of the 17th Brazilian Symposium on Computer Graphics and Image Processing (SIBGRAPI'04) pp. 122-129, 2004

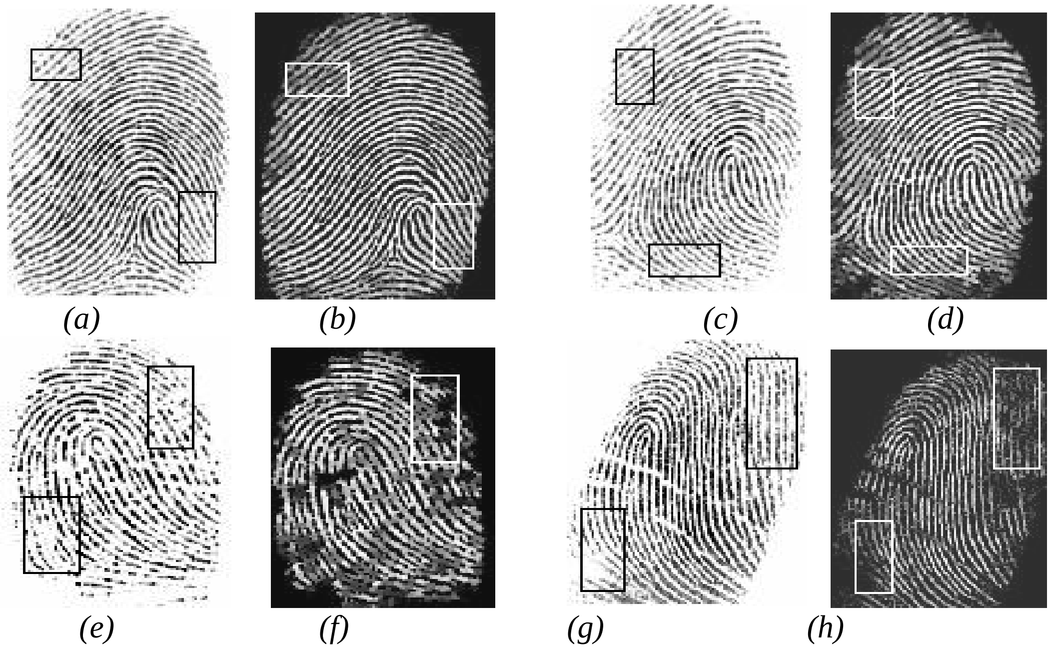


Figure 4:(a), (c), (e) and (g) are Original fingerprint images and (b), (d), (f) and (h) are enhanced image

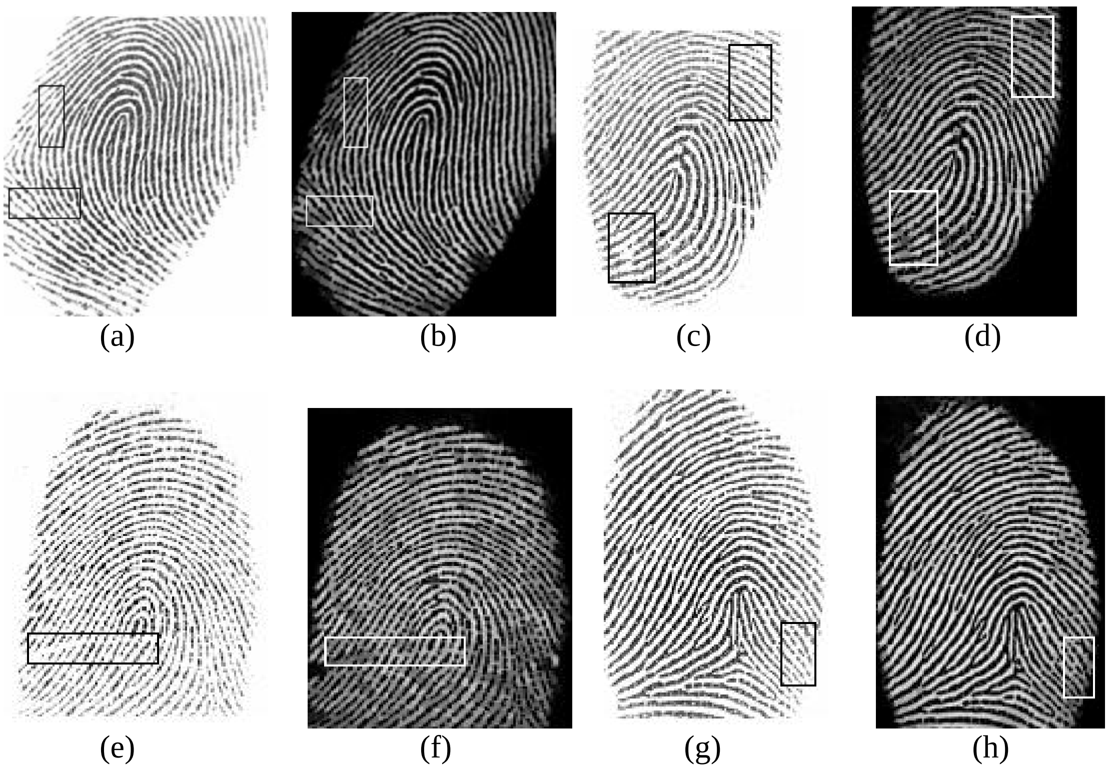


Figure 5: (a),(c),(e) and (d) are original fingerprint images and (b),(d),(f) and (h) are enhanced fingerprint images