Uneven Background Extraction And Segmentation Of Good, Normal And Bad Quality Fingerprint Images

S S Jambhorkar, *S S Gornale,
Department of computer science, SGB Amravati University,
Amravati (MS),India
*VIIT,Baramati,Dist-Pune,(MS) India
sjambhorkar@yahoo.co.in

V T Humbe, R R Manza, K V Kale.
Department of Computer Science &Information Technolgy,
Dr.Babasaheb Ambedkar Marathwada University,
Aurangabad (MS).India
kvkale91@rediffmail.com

***Abstract*- In this paper, we have considered a problem of uneven background extraction and segmentation of good, normal and bad quality fingerprint images, though we propose an algorithm based on morphological transformations. Our result shows that the proposed algorithm can successfully extract the background of good, normal and bad quality images of fingerprint and well segment the foreground area. The algorithm has been tested and executed on FVC2002 database and the performance of proposed algorithm is evaluated through subjective and objective quality measures. This algorithm gives good and promising result and found suitable to remove superfluous information without affecting the structure of fingerprint image as well as reduces the storage space for the resultant image upto 77%. Our results will be useful for precise feature extraction in automatic fingerprint recognition system.**

I INTRODUCTION

In automatic fingerprint recognition system the segmentation of fingerprint images will take a crucial role. The segmentation is concerned with splitting the fingerprint image into regions (foreground and background). It is a basic requirement for the pattern recognition in the image [1]. Segmentation is a basic requirement for the identification and classification of objects in the image. Image processing operations are mainly concentrates on the foreground, which will be necessary to preserve the structure of fingerprint image and extract genuine minutiae from it. So the splitting of the image into two segments must be achieved at earliest stage possible. It is generally believed that image processing bears some fuzziness in nature due to the following factors [2]:

- Information being lost while three dimensional shape or scene is projected into two-dimensional image.
- Lack of the quantitative measurement of image quality.
- Ambiguity and vagueness in some definitions.

(a) (b) (c)

Figure1. (a) Good (b) Normal (c) Bad quality fingerprint images from FVC2002 database..

Accurate segmentation is especially important for the reliable extraction of features like minutiae and singular points. Most feature extraction algorithms extract a lot of false features when applied on un-segmented fingerprint image. Therefore, the main goal of the segmentation algorithm is to discard the background, and reduce the number of false minutiae detection [3]. If we cannot segment the image near the boundary correctly, it can result in a lot of false minutiae, which influence the recognition accuracy badly [4]. Another problem is tackle while dealing with large database and its storage space. Federal Bureau of Investigation (FBI) maintains a large database of fingerprints about 30 millions and the cost of storing all this data runs to hundreds of millions of dollars. The FBI uses eight bits per pixel to define the shade of gray and stores 500 pixels per inch, which work out to about 700000 pixels and 0.7 megabytes per finger to store fingerprints in electronic form [5].

In this paper, a problem of uneven background extraction and segmentation of good, normal, and bad quality fingerprint image (as shown in Figure1) is considered.

II FINGERPRINT SEGMENTATION

A good segmentation should have the following properties [6].

- It should not be sensitive to the contrast in the image.
- It should detect smudged and noisy regions.
- The result of segmentation should be independent of whether the input image is an enhanced image or a raw image.
- It should give consistent result for a variety of images expected by the application.

According to some recent reported work and some application systems, segmentation is nearly an indispensable step; it cannot only decrease the computational cost but also improve the system performance [3, 6, 7, 8]. Segmentation of fingerprint image is essential for detecting smudged and noisy regions and sensitive to the contrast in fingerprint image [9]. It is also necessary to reduce size of data and to eliminating undesired background, which is the noisy and smudged area in favor of the central part of the fingerprint image [10]. Generally, segmentation divides fingerprint image into blocks and calculate the gray-scale variance for each block. If the variance is greater than the global threshold, then the block is assigned to be a foreground region [11]. In [12], the simplest way to segment an image is to perform a thresholding operation using an appropriate threshold and another approach by combining directional field and variance information to make a composite method [6]. The Bazen and Gerez use the mean, variance and additionally coherence. An optimal linear classifier is trained for the classification per pixel while morphology is applied as post processing [3]. However it is confirm that these methods are not found satisfactory for heavily noisy background regions surrounding the poor contrast foreground of fingerprint images. This also fails to separate, background from foreground [13]. One of the common problems in image segmentation is uneven background and poor contrast [14]; some methods are efficient but time consuming [15]. Some background parts cause problem, when direction computation becomes undefined and the input image has perfectly uniform region [6]. In this paper, we have proposed an adaptive algorithm for segmentation and enhancement of low quality fingerprint image.

III METHODOLOGY

Mathematical Morphology refers to a branch of nonlinear image processing and analysis that concentrates on the geometric structure within an image. Mathematical morphology is a comparing the objects contained in an image with known object called Structuring element. When we perform the morphological operation like dilation and erosion the structuring element plays an important role, which is a powerful tool to extract information from images [16,17]. Structuring element is a small grid representing pixels. Where as erosion and dilation are considered the primary morphological operations and the operations of opening and closing are secondary operations and these are implemented using erosion and dilation operations. When we subtract the opened image from the original image is known as Top-hat Transform (T_h) is defined as,

$$T_h = I - (I \circ B) \quad (1)$$

When we subtract the closed image from the original image (I) is known as Bottom-hat Transform (B_h) is defined as,

$$B_h = I - (I \bullet B) \quad (2)$$

Where, I is the image, B is the Structuring element.
In this proposed work firstly, we add the original image to the top hat transform image, and then subtract the bottom-hat transform image i.e. we Perform bottom hat operation on input image by using disk shaped structuring element. Then adjust intensity of the image and repeat both procedures. After that we extract the background of the image by using morphological opening operation having disk shaped structuring element. But here we have used structuring element, which is having exact radius that found good to get satisfied result and then subtract the background from the adjusted image and get final result, which is satisfied and promising.

IV PERFORMANCE EVALUATION

After segmentation; it is often necessary to measure the performance of original and resultant image. There are many quality measures that are used like Mean, variance, directional contrast, mean square error, peak signal to noise ratio and Fourier spectrum etc. In this work we have used Mean, Standard deviation, mean square error (MSE), peak signal to noise ratio (PSNR) and Fourier spectrum, which are more useful to measure the quality of the fingerprint image. *Mean* is the ridge valley structure appear black and white lines on the fingerprint image and the background is rather white, the average gray value of the picture is useful for segmentation. *Standard deviation* is implication of the ridge valley structure is that the deviation of the intensity is significantly higher on the foreground than on background [18]. *Fourier Spectrum* is superior to the others from the viewpoint of classifying the bad and the good. When a fingerprint image of good quality is converted to a Fourier spectrum image using the FFT, a ring of relatively large magnitude clearly appears around the origin. In contrast, fingerprint images of bad quality do not produce a ring in the Fourier spectrum; it is due to the fact that bad quality images generally have less uniform and less periodic ridge valley structure than good quality images [16, 19].
MSE and *PSNR* are the standard metrics to measure the quality of resultant image compared with original one. Mean Square Error (MSE) is the average of the square of the errors of the two images and define as:

$$MSE = \frac{1}{MN} \sum_{j=1}^{M} \sum_{k=1}^{N} (x_{j,k} - x'_{j,k})^2 \quad (3)$$

Where, the digital image is represented as M X N Matrix. Where, M and N denotes the rows and Columns. While X j,k and X ’ j,k denoted the pixel values of original and compressed image respectively.
A common measure is the PSNR, higher PSNR values implies closer resemblance between the resultant and original image and defined as [20]:

$$PSNR = 10 \log(255^2 / MSE) \quad (4)$$

V RESULTS AND DISCUSSION

In this experimental work, we have focused how to extract and segment structured background pattern and how to enhance weak ridge information from given input images. The performance of the proposed technique is measured on FVC2002 fingerprint database. From this database we have selected good, normal and bad quality fingerprint images from db1, db2, db3 and db4, which consist of 3200 fingerprint images. We classify these images according to their quality and their properties [21]. Out of these we have shown here three from db1, db2, db3, & db4 (i.e. 12 images), in Table3. The test result shows our method can distinguish the clear ridge region and the noise region. The accuracy and robustness of output image is achieved for all types/quality images as shown in Table3, also it shows much better correspondence with human intuition by fourier spectrum. Table1 & Figure3 shows its effectiveness on the basis of statistical data. As well as it gave good storage space reduction ratio; we have compared storage space of original image and segmented image and found the major difference between required storage size. We have given the ratio of storage space reduction in Table2 and the variation in storage space for different images is shown in Figure2.

Our proposed technique produces better results than common techniques such as the segmentation based on directional images and segmentation based on variance, where small curly regions produced by less significant regions in segmentation were not eliminated. The proposed algorithm indeed provides: Clear extracted background area, a well-segmented foreground fingerprint image; Enhanced fingerprint image result; and also it reduces the storage space.

VI CONCLUSION

In this paper, we have proposed morphological transformation based algorithm for uneven background extraction and segmentation of good, normal and bad quality fingerprint images. Proposed algorithm successfully extracts the background area and well segment the foreground area. It gives good and promising results as well as found suitable to remove superfluous information without affecting the structure of fingerprint image. It also reduces storage space for resultant image up to 77%. The output of the proposed algorithm will much useful for feature extraction or minutiae detection in fingerprint recognition system, which will helpful to improve the performance of recognition system.

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DB	Image Quality	Original Image		Resultant Image			
		MEAN	STD	MEAN	STD	MSE	PSNR
db1	Good	200.9530	75.9899	81.1233	112.2668	161.9427	59.9528
	Normal	218.7780	61.1166	71.9015	108.7142	171.0991	59.4028
	Bad	239.0932	42.8924	61.8032	101.3216	172.9097	59.2976
db2	Good	135.1551	50.9827	84.8361	92.6253	61.0423	69.7096
	Normal	136.0661	47.6940	98.3004	98.4739	66.3873	68.8702
	Bad	155.4523	42.0860	102.8707	99.3975	57.1925	70.3611
db3	Good	88.1844	33.2630	109.0547	100.3281	85.4068	66.3510
	Normal	105.9620	30.6154	116.9487	90.7238	55.8759	70.5939
	Bad	113.2457	28.0087	112.9054	80.8552	38.8562	74.2266
db4	Good	140.5466	56.4556	87.4200	105.1512	77.1254	67.3710
	Normal	159.4182	37.6980	82.8407	97.8690	66.8383	68.8025
	Bad	158.9946	29.9417	97.7841	98.4907	56.5535	70.4734

Table1. Shows the Mean, Standard Deviation, Mean-Square Error and Peak Signal to Noise Ratio of Original and Resultant Image.

Database	Image Quality	Original Image Size (KB)	Resultant Image size (KB)	Space Reduction Ratio (%)
db1	Good	144	32	77.78
	Normal	144	32	77.78
	Bad	144	32	77.78
db2	Good	176	64	63.64
	Normal	176	64	63.64
	Bad	176	64	63.64
db3	Good	96	64	33.34
	Normal	96	64	33.34
	Bad	96	64	33.34
db4	Good	112	64	42.86
	Normal	112	64	42.86
	Bad	112	64	42.86

Table2. Shows the Storage size on disk for original and segmented image and Size reduction ratio (%).

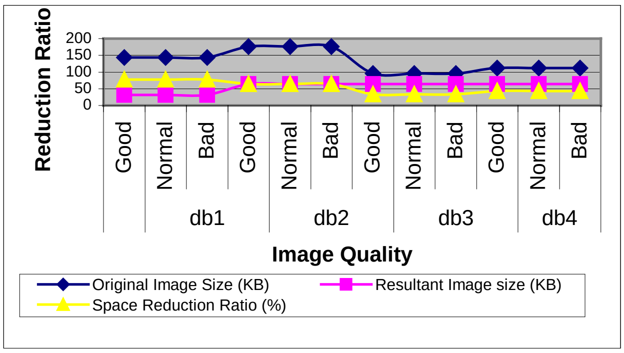


Figure2. Shows comparative analysis of storage size for Original and Segmented image and Storage size reduction ratio (%).

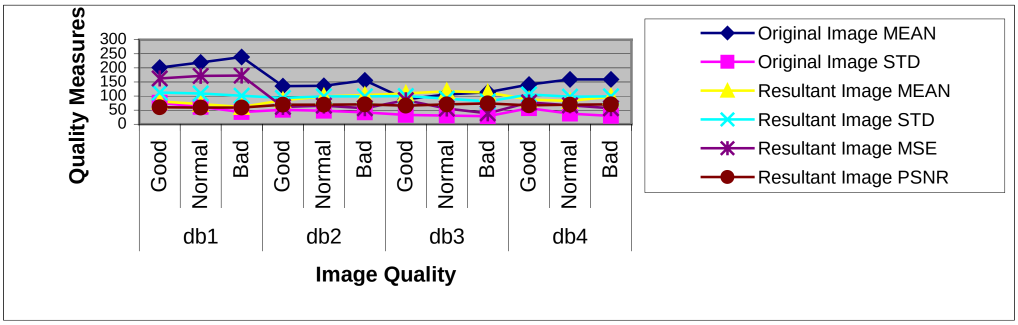


Figure3. Shows variations in Mean, Standard Deviation, Mean-Square Error and Peak Signal to Noise Ratio of all four set of databases db1, db2, db3, and db4.

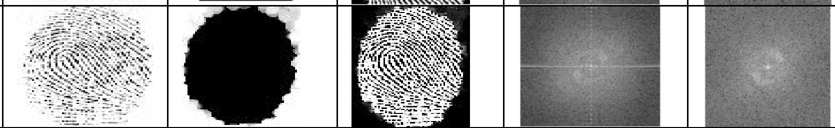
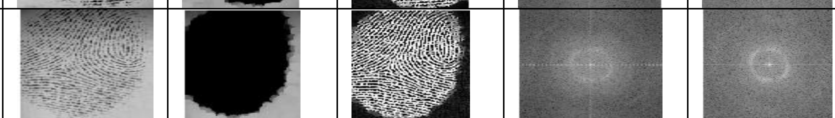
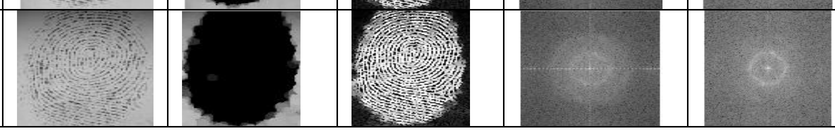
Database FVC2002	Image Quality	Original Image	Extracted Background	Resultant Image	Fourier Spectrum of Original Image	Fourier Spectrum of Resultant Image
db1	Good					
	Normal					
	Bad					
db2	Good					
	Normal					
	Bad					
db3	Good					
	Normal					
	Bad					
db4	Good					
	Normal					
	Bad					

Table3. Shows the Original image, Extracted Background of Original Image, Resultant image, Fourier Spectrum of Original and Resultant Image