Fingerprint: A Dominant Biometric Trait for Next Generation

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***Abstract*— Fingerprint biometrics is largely regarded as an accurate biometric recognition method. A significant research effort has gone into these areas and a number of research works were published, but still there is an immense shortage of accurate and robust methods and techniques. In this research paper the comparative study of different enhancement technique for different standard databases to reduce error and failure rates of automated fingerprint recognition systems. Peak signal-to-noise ratio (PSNR) for analysis of linear filtering and non-linear Filtering on FVC2000, FVC2002, and FVC2004 fingerprint databases.**

Keywords-component; Biometric, Fingerprint Enhancement, Linear Filtering, Nonlinear filtering

I. INTRODUCTION

Fingerprint biometrics is largely regarded as an accurate biometric recognition method. In order to improve the performance of an automatic fingerprint identification system the input fingerprint image requires adaptive enhancement [1].Many cause are responsible for creating noise during fingerprint sensing. The noise may be Random Impulsive Noise, Gaussian Noise, Salt & Pepper Noise, Speckle Noise and Poisson Noise [2].We used different kind of (linear or non-linear) filtering techniques to remove different noise in different databases. First studied FVC databases, found peak signal-to-noise ratio for different databases with same linear or nonlinear filtering. It means that different enhancement techniques are required for different fingerprint image databases depending on the noise present in it.

II. FILTERING TECHNIQUES

Filtering is a technique for modifying or enhancing an image. Filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel. Different methods of filtering can use to remove different types of noise [2].

A. Linear Filtering

Linear filtering is filtering in which the value of an output pixel is a linear combination of the values of the pixels in the input pixel's neighborhood. Linear filters are based on a filter kernel that is convoluted with an image or in the one dimensional case, a curve. The Linear filter kernels provided are divided into different categories viz., Smoothing (Low Pass, Mean, and Gaussian), Sharpening (High Pass) and Edge enhancement. The mathematical description of a convolution with a filter kernel K of size N x M and an Image (I) is described below.

$$C(x,y) = \frac{1}{k} \sum_{i=-N/2}^{N/2} \sum_{j=-M/2}^{M/2} K(i,j) I(x-i, y-j)$$

To avoid a general amplification of the data the sum of products are normally scaled by a factor of 1/k, where k is the sum of the kernel coefficients.

B. Non-Linear Filtering

According to a negative definition, a nonlinear filter is any filter that does not meet the criteria of linearity. There are three types of non-linear spatial filters Median filtering (for noise removal), Outlier Objects Filter (for recovery of areas covered by contamination and spike removal) and Statistical Differencing (for contrast enhancement).

III. EXPERIMENTS, RESULTS AND DISCUSSION

The robustness of the recognition system can be improved by incorporating an enhancement. A single filter that operates on the entire image is not suitable due to the non-stationary nature of the fingerprint image. Hence linear Gabor filter and non linear Median filter has been used. The figure 1 shows the flow of the experiment.

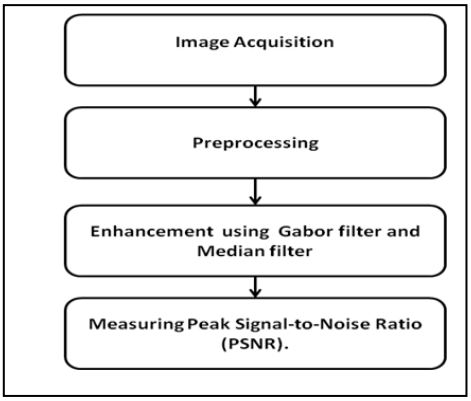

Figure 1. Major working blocks of our system

Gabor Filter to Remove Noise: The 2-D Gabor filter used to remove grain noise from a image, because each pixel gets set to the average of the pixels in its neighborhood, local variations caused by grain are reduced but with blurring of edges[2]. The 2-D Gabor function has been recognized as a very useful tool in computer vision and image processing, especially for texture analysis, due to its optimal localization properties in both spatial and frequency domain [3].The configurations of parallel ridges and valleys with well defined frequency and orientation in a fingerprint image provide useful information which helps in removing undesired noise. 2-D Gabor filters have both frequency-selective and orientation-selective properties and have optimal joint resolution in both spatial and frequency domains [4]. Therefore, it is appropriate to use 2-D Gabor filters as band-pass filters to remove the noise and preserve true ridge/valley structures [5]. 2-D Gabor filter has the following form:

$$\frac{(x_\theta^2 - \sigma_\theta^2)(y_\theta^2 - \sigma_\theta^2)}{2\pi\sigma_\theta^{10}} exp(x_\theta^2 + y_\theta^2)$$

$$x_\theta = x\ cos\ \theta + y\ sin\ \theta$$

$$y_\theta = -x$$

Further modified above equation as shown below

$$g(x, y: \emptyset) = \frac{(x_\theta^2 - \sigma_\theta^2)(y_\theta^2 - \sigma_\theta^2)}{2\pi\sigma_\theta^{10}} exp(x_\theta^2 + y_\theta^2)\cos(2\pi f x_\theta)$$

Where, θ is the orientation of the second filter, f is the frequency of a sinusoidal plane wave, σ_θ ($\sigma_\theta =$ 4) is the standard deviations of the Gaussian envelope. x_θ and y_θ define the x and y axes of the filter coordinate frame.

Median Filter to Remove Noise: At the next stage of experiment, apply the non-linear Median Filter for noise removal. Median Filter is a non-linear smoothing method that reduces the blurring of edges, in which the idea is to replace the current point in the image by the median of the brightness in its neighborhood. Individual noise spikes do not affect the median of the brightness in the neighborhood and so median smoothing eliminates impulse noise quite well [6]. Median filter is a better filtering technique according to performance and takes less computational time. It smooth salt and pepper noises [7]. The median filter is an effective method that can suppress isolated noise without blurring sharp edges. Specifically, the median filter replaces a pixel by the median of all pixels in the neighborhood. Mathematically, the median filter is represented as:

$$y[m, n] = median\{x[i, j], (i, j) \in w\}$$

Where w represents a neighborhood centered on location (m, n) in the image. Following figure shows the enhancement results. We have applied these Gabor-Filter and Median Filter on FVC 2000, FVC2002, and FVC2004 fingerprint database.

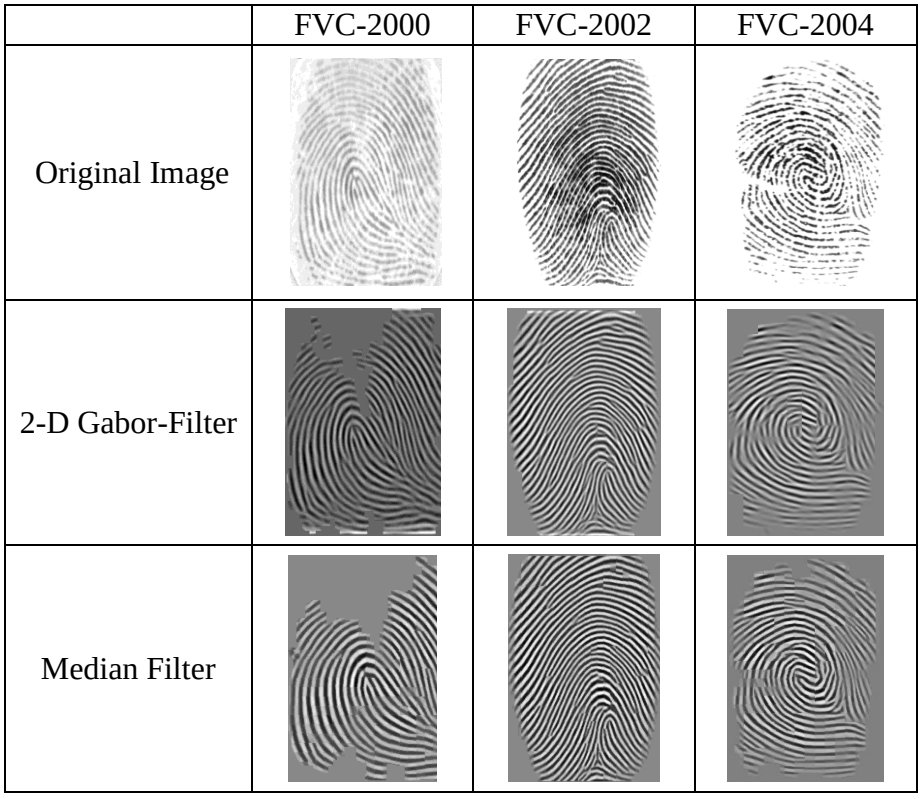

Figure 2. Enhancement results using Gabor-Filter and Median Filter on FVC2000, FVC2002, and FVC2004 database

To measure performance of fingerprint enhancement peak signal-to-noise ratio (PSNR) has been calculated. The PSNR computes the peak signal-to-noise ratio and represents a measure of the peak error in decibels, between two images. This ratio is often used as a quality measurement between the original and a reconstructed (enhanced) image. It is most easily defined via the mean squared error (MSE) which for two m×n monochrome images I and K where one of the images is considered as a noisy approximation of the other, it is defined as:

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

$$PSNR = 10.log_{10}\left(\frac{MAX^2}{MSE}\right)$$

Here, MAX is the maximum possible pixel value of the image. Following table shows the comparative study of fingerprint enhancement using Gabor filter and Median Filter by measuring peak signal-to-noise ratio (PSNR).

Enhancement Technique	**Peak Signal-to-Noise Ratio (PSNR).**		
	FVC2000	***FVC2002***	***FVC2004***
2-D Gabor-Filter	11.35 Decibel	15.45 Decibel	8.027Decibel
Median Filter	10.25 Decibel	12.54 Decibel	8.71 Decibel

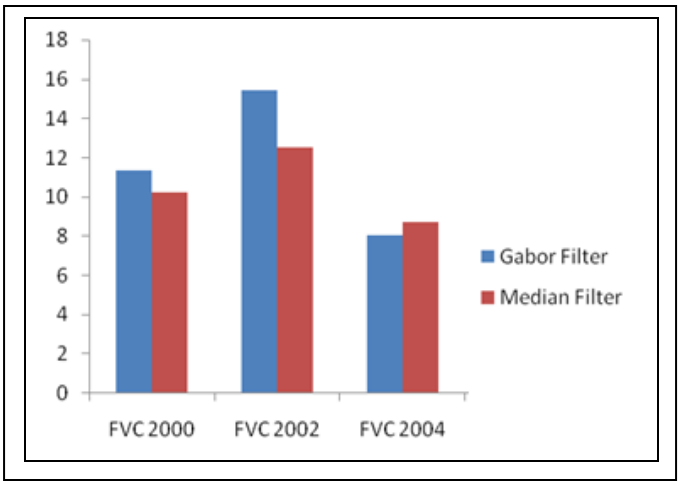

Figure 3. Peak Signal-to-Noise Ratio (PSNR)

IV. CONCLUSION

As per the experiment worked on different databases having different noise present in it and apply different filtering techniques like linear filtering and non linear filtering to remove different type of noise. And found that to remove different type of noise we can apply different filtering techniques and algorithms depending on the noise present in the images. The results shows 2-D Gabor-Filter gives highest PSNR for FVC 2000 and FVC 2002 Fingerprint Image Databases while as compare to the 2-D Gabor-Filter Median Filter gives highest PSNR for FVC 2004 Fingerprint Image database.

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