Improvising MSN and PSNR for Finger-Print Image noised by GAUSSIAN and SALT & PEPPER

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ABSTRACT

Image de-noising is a vital concern in image processing. Out of different available method wavelet thresolding method is one of the important approaches for image de-noises. In this paper we propose an adaptive method of image de-noising in the wavelet sub-band domain assuming the images to be contaminated with noise based on threshold estimation for each sub-band. Under this framework the proposed technique estimates the threshold level by apply sub-band of each decomposition level. This paper entails the development of a new MATLAB function based on our algorithm. The experimental evaluation of our proposition reveals that our method removes noise more effectively than the in-built function provided by MATLAB .One of its applications for Fingerprint de-noise due to importance of fingerprint for day-to-day life especially in computer security purposes. Fingerprint acts as a vital role for user authentication as it is unique and not duplicated. Unfortunately allusion Fingerprints may get corrupted and polluted with noise during possession, transmission or retrieval from storage media. Many image processing algorithms such as pattern recognition need a clean fingerprint image to work effectively which in turn needs effective ways of de-noising such images. We apply our proposed algorithm and compare other traditional algorithms for different noises.

KEYWORDS

Fingerprint Image De-noise, Wavelet Thresholding , Gaussian noise , Salt & Pepper noise, Discrete Wavelet Transform.

1. INTRODUCTION

Reserving the details of the image and removing the noise as far as possible is the goal of image de-noising. According to character, type of noise and for higher level processing each noised image is required for de-noise with appropriate de-noising technique. There are diverse methods to help restore an image from strident distortions. Selecting the appropriate method plays a major role in getting the desired image to solve the de-noising problems in image analysis and pattern

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recognition. Generally, the de- noising techniques have been categorized into spatial and frequency domain techniques. The past experience has reveals that the wavelet technique is an efficient technique in comparison of others Because the wavelet transformation has many merits, such as low entropy, multi-resolutions, de-correlation and flexibility to select wavelet primary function. In this paper a new shrinkage wavelet transformation method is proposed using the global threshold value, normalise it with all de- composed components and find out the rescaled threshold value. This method is an efficient technique compared to the MATLAB wavelet transformation and the various linear and non-linear spatial techniques.

Finger print images have uniqueness and persistence, which are highly desirable qualities for biometric applications and software security apprehensions. However, finger print images are generally of low contrast, due to skin conditions and application of inaccurate finger pressure. Also, they inherently contain complex type of noise, originating from two distinctive sources, such as the set of various devices involved in the acquirement, transmission, storage and display of the image and noise arising from the application of different types of quantization, reconstruction and enrichment algorithms. It is certain that every imaging method inherently engross noise. Many dots can be spotted in a Photograph of fingerprint taken with a digital camera or fingerprint reader under low lighting conditions or the machine hardware problem. Actually this type of noise is the uniform Gaussian noise. Emergence of dots is due to the real signals getting corrupted by noise (surplus signals). On loss of reception or retrieve any Fingerprint image from the storage device random black and white snow-like patterns can be seen on the Fingerprint images. This type of noise is called Salt & Pepper noise. The basis of the de-noising algorithm is to remove and confiscate such noise.

In this paper first the testing fingerprint image is noised with the Gaussian and Salt & Pepper noise differently. After that the proposed wavelet transformation is adapted in order to de-noise the fingerprint images, followed with the various other methods such as mean filter, median filter, library Matlab wavelet transformation techniques to de-noise the fingerprints image and lastly check which one is the best in terms of Pick signal to noise ratio(PSNR), Mean square error(MSE).

The paper is organized as follows. Section 2 speaks about to the existing work completed in fingerprint de-noising whereas section 3 show succinct introduction different noises especially Gaussian and Salt-Pepper noise. Section 4 and 5 describes about mean and median filter and basics of wavelet transform and fingerprint de-noising respectively. In section 6, new approach for fingerprint de-noising along with algorithm design is mentioned. The proposed work is detailed in section 7 followed by conclusion in section 8.

2. RELATED WORK

Maltoni D. Has proposed various methods and problems for fingerprint recognition. He has given idea how fingerprint get different noises with different stages of processing [1]. Louise has proposed fingerprint recognition for low quality images and emphasized upon ridge detection and Improved algorithms for enhancement of fingerprint images[2]. S.G.mallat described how to singularity detection using the wavelet transformation. Amra Graps uses the various wavelet technique as well as its importance from other de-noising techniques [4,8]. Rakesh has given the idea in order to utilise the wavelet transformation in fingerprint recognition [6]. Gornale S.S has given the idea to de-noise fingerprint using multi-resolution analysis through stationary wavelet transformation, which have the adaptive normalization based on block processing, are proposed. A direction stream field of the ridges is computed for the fingerprint image. To accurately locate ridges, a ridge orientation based computation scheme is used [5]. But this method used the library Matlab function which is less efficient in order to de-noise. Zhen_bing Zhao has given a better idea for de-noising using wavelet transformation based on noise standard deviation estimation [3]. So the fingerprint image transformed by wavelet domain by an efficient way de-noise gives a better result and fulfils various authentication and pattern recognition methods.

3. DIFFERENT TYPES OF NOISE

In real life scenario different versions of noises found such as Gaussian, Salt-Pepper, Rician, Speckle etc. They broadly classified into additive and multicative noises. Our discussion mainly based on Gaussian and Salt–pepper noise as normally Fingerprint affected with this type of noise. So we briefly discuss about this type of noise.

3.1 Gaussian Noise

Gaussian noise one of the widespread noise which consistently distributed over the signal [17]. This means that each pixel in the noisy image is the sum of the true pixel value and a random Gaussian distributed noise value. As the name indicates, this type of noise has a Gaussian distribution, which has a bell shaped probability distribution function given by,

$$F(g) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(g-m)^2/2\sigma^2}, \tag{3.1}$$

where g represents the gray level, m is the mean or average of the function, and σ is the standard deviation of the noise. Graphically, it is represented as shown in Figure 3.1.

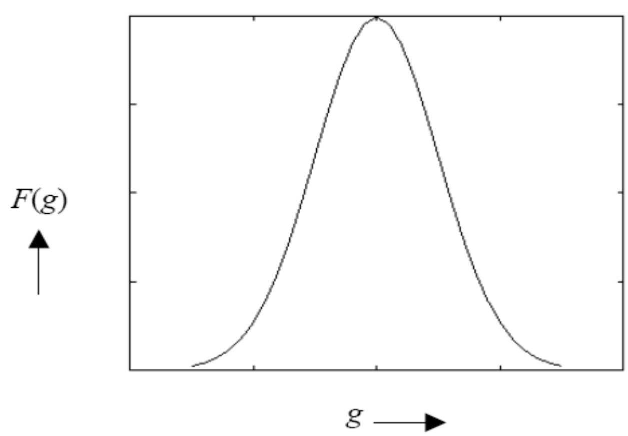

Figure 3.1 Gaussian distribution

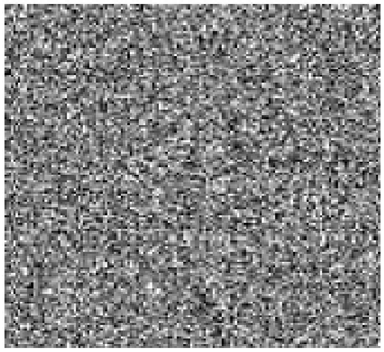

Image 3.2: Gaussian noise
(mean=0, variance 0.05)

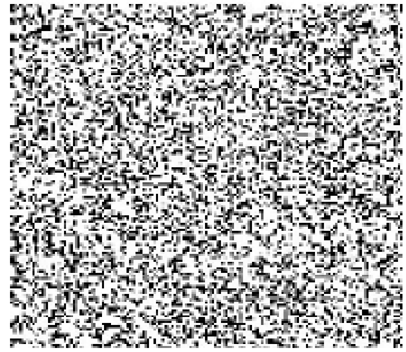

Image 3.3: Gaussian noise
(mean=1.5, variance 10)

3.2 Salt and Pepper Noise

Salt and pepper noise [17] is This is caused generally due to errors in data transmission. It has only two feasible values, a and b. In Grey Image similar to fingerprint the a and b value is 0 and 255 respectively. The probability of each is normally less than 0.1. The contaminated pixels are set alternatively to the minimum or to the maximum value, generous the image a "salt and pepper" like sign. Impervious pixels remain unchanged. The salt and pepper noise is generally caused by not working of pixel elements in the camera sensors, defective memory locations, or timing inaccuracies in the digitization process. Salt and pepper noise with a variance of 0.05 is shown in Image 3.4

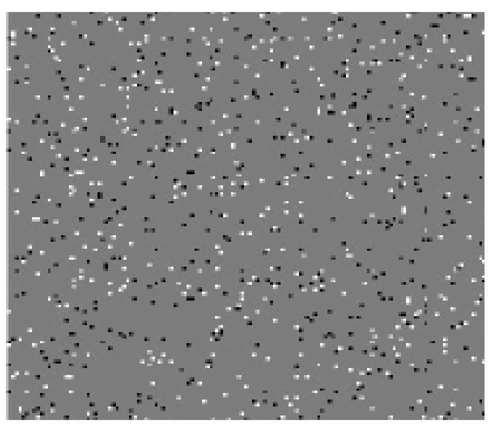

Figure 3.4: Salt and pepper noise

4. TRADITIONAL FILTERING TECHNIQUES

4.1 Mean Filter

A mean filter is a linear spatial filter. It acts on an image by reducing the intensity variation between adjacent pixels. The mean filter is nothing but a simple sliding window spatial filter that replaces the centre value in the window with the average of all the neighbouring pixel values including itself. By doing this, it replaces pixels that are unrepresentative of their surroundings. It is implemented with a convolution mask, which provides a result that is a weighted sum of the values of a pixel and its neighbours.

The mask or kernel is a square. Often a 3×3,4x4, 5x5 square kernels are used.In this paper we use the 3x3 kernel. If the coefficients of the mask sum up to one, then the average brightness of the image is unchanged. Otherwise the brightness of the image may lost or effected. The mean or average filter works on the shift-multiply-sum principle . This principle in the two-dimensional image can be represented as shown below .The mask used here is a 3× 3 kernel shown in Figure . Note that the coefficients of this mask sum to one, so the image brightness is retained, and the coefficients are all positive,

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

Figure 4.1 : A constant weight 3× 3 filter mask

Example For the following 3×3 neighborhood, mean filtering is applied by convoluting it with the filter mask

$$\begin{bmatrix} 70 & 58 & 63 \\ 66 & 200 & 62 \\ 61 & 57 & 65 \end{bmatrix} \times \begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix}$$

This provides a calculated value of 78. Note that the center value 200, in the pixel matrix, is replaced with this calculated value 78. This clearly demonstrates the mean filtering process.

4.2 Median Filter

A median filter is a nonlinear filters contrasting the mean filter. The median filter as well pursues the moving window principle like to the mean filter. A 3×3, 5× 5, or 7× 7 kernel of pixels is inspected over pixel matrix of the entire image. The median of the pixel values in the window is worked out, and the center pixel of the window is substituted with the computed median. Median filtering is done by, first sorting all the pixel values from the adjacent neighbourhood into numerical order and then replacing the pixel being considered with the middle pixel value. Note that the median value must be written to a separate array or buffer so that the results are not corrupted as the process is performed..

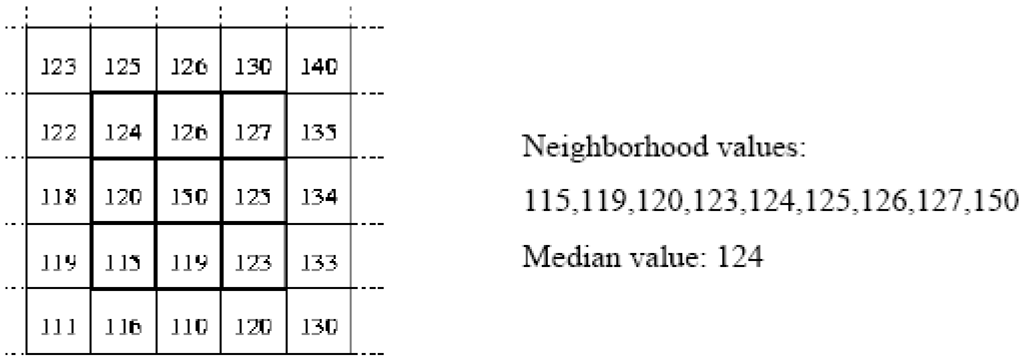

Figure 4.2: Concept of median filtering

The centered pixel whose value is 150 in the 3×3 window shown in Figure 3.3 is rather misleading of the surrounding pixels and is replaced with the median value of 124. The median is more robust compared to the mean. Thus, a single very unreliable pixel in a neighbourhood will not influence the median value significantly. We can get an excellent picture quality from the median filter compared to the mean filter.

5. METHODOLOGY

5.1 Wavelet Transform

Basically image de-noising performances are fall into two fundamental categories namely spatial domain and frequency domain. Wavelet Transform (WT) is one of the frequency domain techniques emerged as very powerful tool and provide a vehicle for digital image processing applications.

A wavelet is a small wave with finite energy, which has its energy concentrated in time or space area to give ability for the analysis of time-varying phenomenon in other words it provides a time-frequency representation of the signal. Wavelet has compensation in analyzing physical situations where the signal includes discontinuities and jagged spikes. Wavelet transform of any function f (t) represented as

$$\gamma(s,\tau) = \int f(t)\psi_{s,\tau}(t)dt \tag{5.1}$$

This equation shows how a function $f(t)$ is decomposed into a set of basis functions called the wavelets. The variables s and Ω, scale and translation, are the new dimensions after the wavelet transform.

Inverse wavelet transformation can be expressed as:

$$f(t) = \iint \gamma(s,\tau)\psi_{s,\tau}(t)d\tau ds \tag{5.2}$$

The wavelets are generated from a single basic wavelet $\psi(t)$, the so-called *mother wavelet*, by scaling and translation:

$$\psi_{s,\tau}(t) = \frac{1}{\sqrt{s}}\psi\left(\frac{t-\tau}{s}\right) \tag{5.3}$$

Concerning wavelet transform on 1D signal, it can accurately sense the singularity in a signal. For images, the 2D scaling function $\varphi(x, y)$ and mother wavelet $\psi(x, y)$,which is calculated as tensor products of the following 1-D wavelets $\psi(x)$, $\psi(y)$ and scaling functions $\varphi(x)$,$\varphi(y)$.

Scaling function
$\varphi(x, y) = \varphi(x)\times\varphi(y)$ (5.4)

Vertical wavelets
$\psi y(x, y) = s(x)\times\psi(y)$ (5.5)

Horizontal wavelets
$\psi x(x, y) = \psi(x)\times s(y)$ (5.6)

Diagonal wavelets
$\psi d(x, y) = \psi(x)\times\psi(y)$ (5.7)

The use of wavelet transform on image proves that the transform can analyze singularities effortlessly that are horizontal, vertical or diagonal.

5.2 Wavelet Thresholding

Image de-noising is used to get rid of the additive noise while keeping hold of as much as possible the important features. Wavelet thresholding is an effective method which is achieved via thresholding. Wavelet thresholding procedure removes noise by thresholding only the wavelet coefficient of the details coefficients, by keeping the low-resolution coefficients unaltered. There are two thresholding methods commonly used as: soft thresholding and hard thresholding.

The hard-thresholding TH can be defined as

$$T_H = \begin{cases} x & \text{for } |x| \geq t \\ 0 & \text{in all other regions.} \end{cases} \quad (5.8)$$

Here t is the threshold value. TH is shown in Figure

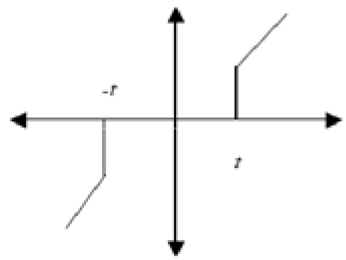

Figure 5.1: Hard thresholding

Soft thresholding is where the coefficients with greater than the threshold are shrunk towards zero after comparing them to a threshold value. It is defined as follows in all other regions.

$$T_s = \begin{cases} \text{sign}(x)(|x| - t) & \text{for } |x| > t \\ 0 & \text{in all other regions.} \end{cases} \quad (5.9)$$

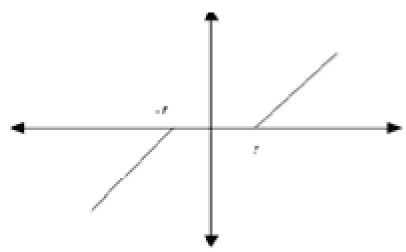

Figure 5.2: Soft thresholding

In practice, it can be seen that the soft method is much better and yields more visually pleasant images. This is because the hard method is discontinuous and yields abrupt artifacts in the recovered images.

6. FINGERPRINT DE-NOISING

A fingerprint image consists of non-ridge area, high quality ridge area, and low quality ridge area. It is well known that low quality ridge area in the fingerprint images would cause serious effects, which deteriorate the quality of the image. The Fingerprint image is infected with the Gaussian and Salt & Pepper noise. Many dots can be spotted in a Photograph of fingerprint taken with a digital camera or fingerprint reader under low lighting conditions or the machine hardware problem. Actually this type of noise is the uniform Gaussian noise. Facade of dots is due to the real signals getting corrupted by noise (superfluous signals). On loss of reception or recover any Fingerprint image from the storage device random black and white snow-like patterns can be seen on the Fingerprint images. This type of noise is called Salt & Pepper noise. The resulting sub-image is extracted from the original fingerprint image with noise in the complex wavelet transform domain. Then, according to the characteristics of the sub-image data, the de-noised fingerprint is being used for further reference purposes.

7. ALGORITHM DESIGN

Having fully analyzed the different condition characteristic of the useful signal and the noise in wavelet transformation domain, the above wavelet de-noising theory and corrected noise-estimate method are adopted to smooth the noise. This article proposed the image de-noising method based on the noise standard deviation estimation, normalize each detailed component, finding out the appropriate threshold value realizing steps are as follows:

- Add the Gaussian noise and Salt & Pepper noise to the reference fingerprint Image.
- Carry on the multi-scale wavelet decomposition to the observed image $f(x, y)$ and obtain the low and the high frequency coefficients of each level.
- Estimate the noise standard deviation σ by using the detail coefficients.
- Determine the threshold value t by using the normalization of each level and producing the threshold value by global threshold method.
- Use soft-threshold/hard-threshold function to make threshold processing to the each frequency coefficient, and obtained the estimate coefficient.
- Realize de-noising and reconstruction by making wavelet inverse transformation to the low frequency coefficients and the processed high frequency coefficients.

8. RESULTS AND DISCUSSION

This section shows the proposed method which consists different modules. In first module the test fingerprint Image is noised with Gaussian or Salt & Pepper noise. Then the noised image is De-noised by the proposed wavelet transformation which is described in the algorithm. At each level, the wavelet transform decompose the given image into three components, i.e. horizontal, diagonal and vertical detail sub-bands.

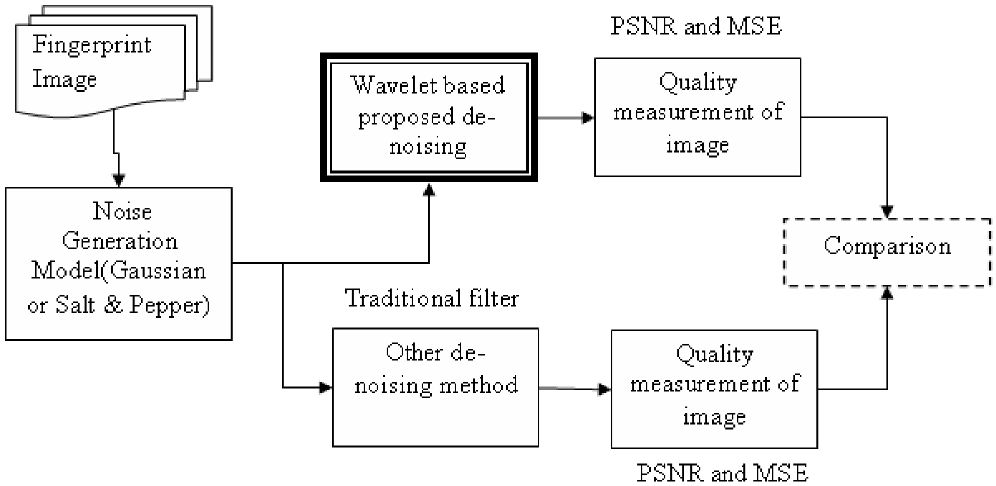

Figure 8.1: Overall work layout

In next module the tested fingerprint Image is de-noised by mean, median and Matlab available wavelet function. Lastly every de-noised algorithms are evaluated with the MSE and PSNR for quality measurement.We have use Matlab 7.0 to noised and de-noised the fingerprint image by anticipated wavelet transformation, Library wavelet transformation, Mean and Median techniques. And different outputs of the programs are shown below.

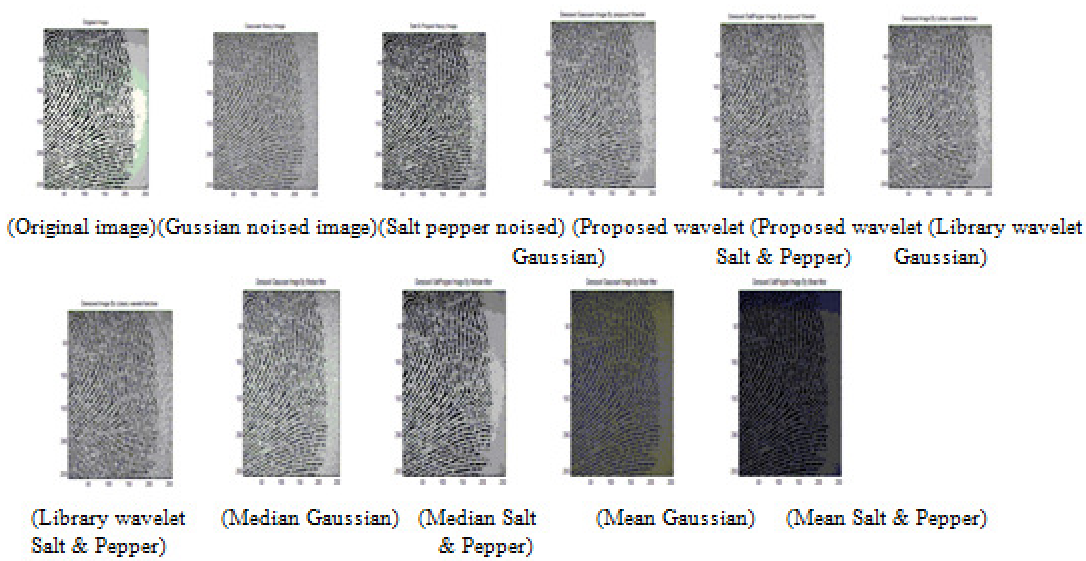

Figure 8.2: experimental results

In this section deals with the comparison and constraction of the de-noising procedures .The Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) of the output image is calculated which acts as a quantitative standard for comparison. The Peak Signal to Noise Ratio (PSNR) is most commonly used as a measure of excellence of reconstruction in image firmness and image de-noising mechanism . It comes from mean square error (MSE). MSE of two images are defined as

$$\mathrm{MSE} = \frac{1}{mn}\left(\sum_{i=0}^{m-1} \sum_{j=0}^{n-1} (I(i,j) - R(i,j))^2 \right)$$

where I and R can be interpreted as input and reconstructed images respectively. m and n defines number of pixel in vertical and horizontal dimension of images I and R. Then the PSNR is de fined as

$$\mathrm{PSNR} = 10.\log_{10}\left(MAX_I^2 / MSE\right) = 20.\log_{10}\left(MAX_I / \sqrt{MSE} \right)$$

where MAX_I is the maximum pixel value of the image I.

Tables 1 shows the MSE and PSNR of the input and output images for all the filtering approach and wavelet transform approach

METHOD	MSE Input Image	MSE Output Image	PSNR Input Image	PSNR Output Image	Noise Type
Proposed wavelet	397.1845	271.2540	22.1409	24.7970	Gaussian noise
Proposed wavelet	420.4853	201.8078	21.8933	25.0814	Salt & pepper noise
Matlab based Wavelet	397.1845	273.2360	22.1409	24.7654	Gaussian noise
Matlab based Wavelet	420.4853	218.2534	21.8933	23.1031	Salt & pepper noise
Mean Filter	397.1845	298.1709	22.1409	22.2099	Gaussian noise
Mean filter	420.4853	301.8503	21.8933	22.0899	Salt & pepper noise
Median filter	397.1845	325.3212	22.1409	23.8436	Gaussian noise
Median filter	420.4853	200.0490	21.8933	25.9803	Salt & pepper noise

Table 1: PSNR and MSE for Fingerprint.bmp as test Image

9. CONCLUSION AND FUTURE WORK

In this paper we have seen the wavelet technique is better than the traditional mean and median spatial transformation techniques and the proposed wavelet function also de-noised the fingerprint better than the MATLAB wavelet function for Gaussian noised in terms of PSNR and MSE. If the noise is Salt & pepper type than by using Median filter gives better noise removal. The proposed method also nearly gives better quality as compared the median filter technique and better than other techniques. The de-noised fingerprint which we accomplished, are more helpful for Automatic Fingerprint Recognition Systems or any pattern matching procedure. In future the work can be extended for other type of noises such as speckle noise, rician noise etc. and recover from the blurring effect of the fingerprint.

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