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A Hybrid Filter Consisting Image Denoising and Image Enhancement to Improve the Quality of MRI Images

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Abstract- In this paper , we have proposed a new hybrid model ,in this model there are image denoising and image enhancement techniques to improve the quality of biometrics images on three types of noise such as Salt and Pepper (SPN), Gaussian noise and Speckle (SPKN). Different noise variance has been removed in between .02 to .14 by using different types of filter such as median and High-pass spatial filter. Filter techniques are mainly used for smoothness and sharpening of images and extracting the useful information for the analysis for image processing The same concept is applied to the different images and they are compared with one another. The study is proposed with the help of Mean Square Errors (MSE), Peak-Signal to Noise Ratio (PSNR) and Signal to Noise ratio (SNR).So as to choose the appropriate noise for different filtering methods for any image. Results are simulated on MATLAB R2007b.

Keywords- Different images, image noise, Filter, Smoothness masking, Sharpening masking, PSNR, MSE and SNR

I. INTRODUCTION

Image processing is the most important technique that used into improves the quality of image enhancement. Digital image processing has helped in the access to technical data in digital, services of computers in terms of speed of processing the data and the possibilities of big storage. Several studies can also take the benefit of it such as technical diversity of the digital image processing and maintaining the accuracy of the original data. Noise is removable using iterative median and High pass filter in spatial domain which requires much less processing time than removal by frequency domain Fourier transforms [1].The objective of image enhancement is to improve the quality of image.

The high pass filter will work on high-frequency components of images. Image enhancement techniques emphasize specific image features to improve the visual perception of an image [2].Filtering technique can not remove more than one noise at the same time.

A. Spatial Domain Method:

A spatial domain method is an image operation where each pixel value is changed by a function of the intensities of pixels in a neighbourhood. Spatial domain is a simple manipulation of neighbourhood pixels

II. IMAGE NOISE

Image noise represent unwanted information which degrades the image quality to enhance the quality we use filtering. Noise is defined as process(n) which add with original image(s) and effects the acquired image (o).

$$o(i , j)=s(i ,j)+n(i ,j) \quad (1)$$

A. Types of Noise

There are three different types of noise

a) Salt and Pepper Noise
b) Gaussian Noise
c) Speckle Noise

a. Salt and Pepper Noise:

Salt & pepper noise is random combination of black & white intensity value. We can ensure that image containing noise have dark pixels in bright regions and bright pixels in dark regions is salt and pepper [3]. This type of noise can be caused by dead pixels, analog-to-digital converter errors, bit errors in transmission, etc.

$$P(x) = \begin{cases} P1, & x=A \\ P2, & x=B \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

Where: p1, p2 are the Probabilities Density Function (PDF), p(x) is distribution salt and pepper noise in image and *A, B* are the arrays size image. Salt & Pepper are called impulsive noise.

b. Gaussian Noise:

Gaussian noise is useful for modelling process which introduce noise caused by conversion of optical into an electronic one this type of noise is also called the random variant impulse noise or normal noise is randomly occurs as white intensity values[3]. Gaussian distribution noise can be expressed by:

Gaussian distribution noise can be expressed by:

$$P(x) = 1/(\sigma\sqrt{2\pi}) * e^{(x-\mu)2} / 2\sigma^{2} \quad -\infty < 0 < \infty \quad (3)$$

Where: *P(x)* is the Gaussian distribution noise in image; μ and σ is the mean and standard deviation respectively.

c. Speckle Noise:

Speckle noise is added in the image it is also called multiplicative noise, multiplicative noise is a undesired artifact that limits the interpretation of optical coherence of different images it is dynamic by nature [4]. It increases the mean gray level of a local area .The distribution noise can be expressed by:

$$J = I + n*I \quad (4)$$

Where, *J* is the distribution speckle noise image, *I* is the input image and *n* is the uniform noise image by mean □ and variance *v*.

III.FILTER

The image filtering method is 2D filter matrix, and the 2D image for every pixel of the image, take the sum of products. Where the current pixel is obtained by colour value or a neighbour of it, with the corresponding value of the filter matrix. Filtering method that remove the unwanted noise from image .The centre of the filter matrix has to be multiplied with the current pixel and get the new value, the rest elements of the filter matrix with corresponding neighbour pixels[6].

A. Median Filter:

Median filter is a filtering technique that is non-linear by nature which changes the intensity value of image. Median filter is spatial filter, which change the variance of intensity of image. It is uses 2D filter to calculate the new pixel value of original image [5]. To apply the mask means to centre it in a pixel, calculating the brightness of pixel and determining which brightness value is the median value.

There are number of steps to in median filter to calculate the new pixel value in processing image.

a. The neighbourhood pixels of the pixel in the original image which are calculated by the mask are stored in the ascending or descending order.
b. The median of the stored value is computed and is chosen as the pixel value for the processed image.

B. High-Pass Filtering:

High-pass filtering is a method that is used to high light the essential details through high frequency components. High-pass filter is a spatial filter, it is used for image sharpening and smoothing [6]. Spatial mask which perform image sharpening using following equations:

$$1/9 \times \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

High-pass= original – low-pass (5)

The resulting signal value should be zero that implies the sum of all the weight is zero.

IV.PROPOSED METHODOLOGY

In proposed methodology, we have combined the different filtering techniques into single one is called hybrid filter. There are three different noise sources as possible noises are salt and peppers, Gaussian and speckle noise will be added to original image here we want to improve the quality of image enhancement. The noise will be common for the median filter it is used for de-noising then to improve the quality of image through high-pass filtering. The hybrid model Shown in figure

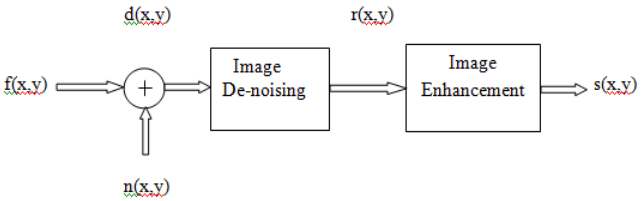


Figure. 1- Hybrid Model

At last s(x,y) output is generated we select the appropriate output and compare with the original image[9].

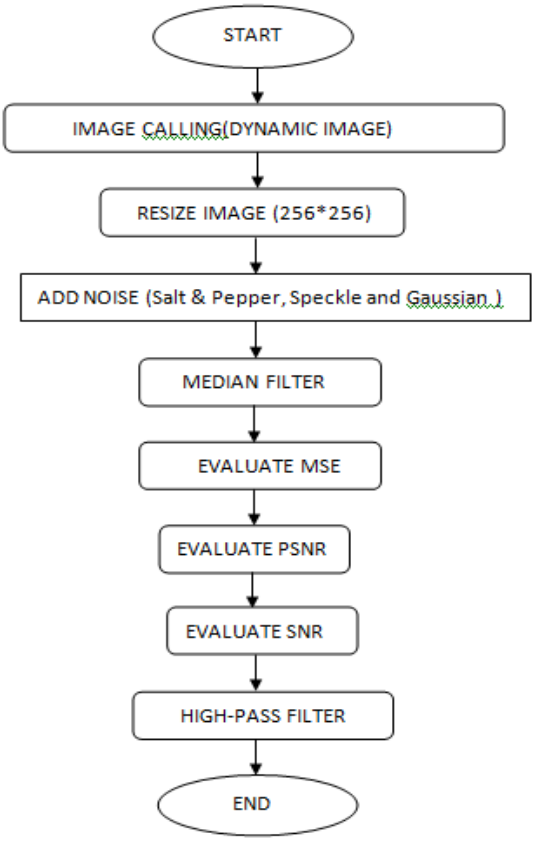


Figure 2- Proposed Method

The MSE is calculated, Given a noise-free mxn monochrome image I and it is noisy approximation *K*, *MSE* is defined as:

$$MSE = \frac{1}{m\,n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \quad (6)$$

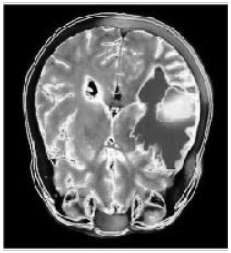
$$PSNR = 10 \cdot \log_{10} \left(\frac{MAX_I^2}{MSE} \right) \quad (7)$$

$$SNR = (P_{signal} / P_{noise}) \quad (8)$$

Where, M and N are the total number of pixels in the horizontal and the vertical dimensions of image where I denotes the original image and K denotes the filtered image.

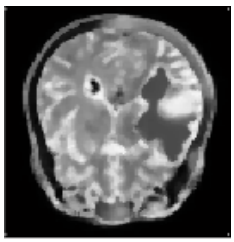
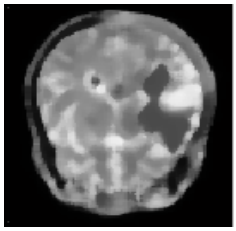
V. SIMULATION RESULTS

Simulation results were carried out for one of the biometrics images this image has been selected for demonstration. The performance measure of filtering techniques quantified by Mean Square Error (MSE), peak Signal to Noise ratio (PSNR) and Signal to Noise ratio (SNR).

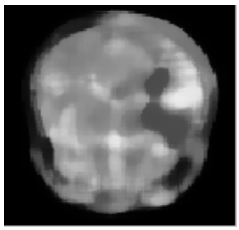
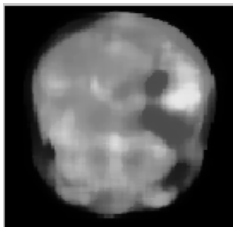



Original Image Noisy Image

Figure 3- Salt and Pepper Noise with .14 variance

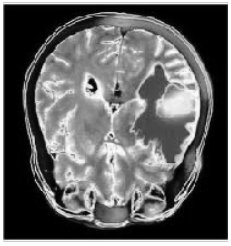



Window Mask 3x3 Window Mask 5x5

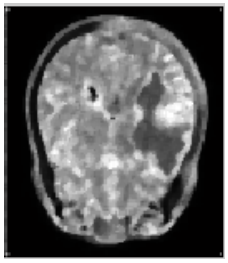
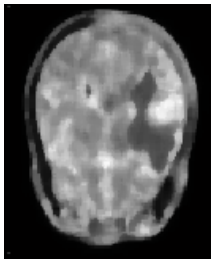
Window Mask 8x8 Window Mask 10x10

Figure 4- Denoised Image of Salt & pepper Using Median Filter

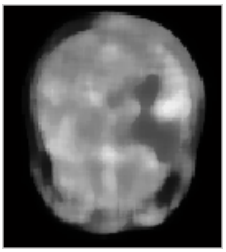
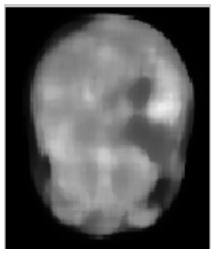



Original Image Noisy Image

Figure.5- Speckle Noise with .14 variance

Window Mask 3x3 Window Mask 5x5

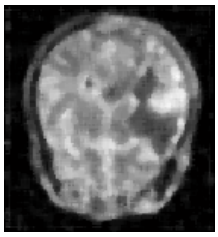



Window Mask 8x8 Window Mask 10x10

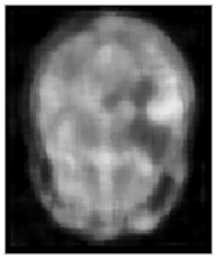
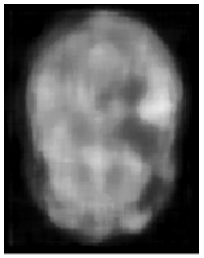
Figure 6- Denoised Image of Speckle Noise Using Median Filter


Original Image Noisy Image

Figure.7- Gaussian Noise with .14 variance

Window Mask 3x3 Window Mask 5x5

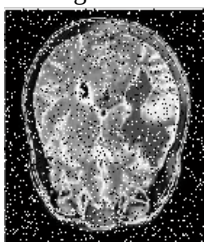



Window Mask 8x8 Window Mask 10x10

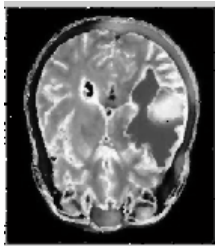
Figure 8- Denoised Image of Gaussian Noise Using Median Filter

There are three different noisy images are generated, In first noisy image where original image is affected by salt & peppers, second affected by speckle and similarly third is affected by Gaussian noise. The output of median filter for all noisy images given above where first output generated after removing salt & peppers by median filter, second output comes after removing speckle and respectively third output after removing Gaussian noise by median filter with different mask.

The output of hybrid model shown in figure below:

Original Image Noisy Image




Filtered Image Sharpened Image

Figure 9- Denoised & Enhancement Image of Salt & Pepper Using Median & Highpass Filter

Table 1: Restoration result PSNR of Salt & pepper

FILTER TYPE	NOISE VARIANCE(Salt & Peppers)						
	.02	.04	.06	.08	.10	.12	.14
MF(3,3)	64.52	63.42	62.48	61.53	61.10	60.76	60.09
MF(5,5)	62.92	62.17	61.40	60.68	60.31	59.97	59.48
MF(8,8)	61.80	61.21	60.62	60.04	59.74	59.41	58.99
MF(10,10)	61.41	60.89	60.35	59.80	59.54	59.20	58.82

Table 2: Restoration result MSE of Salt & pepper

FILTER TYPE	NOISE VARIANCE(Salt & Peppers)						
	.02	.04	.06	.08	.10	.12	.14
MF(3X3)	50.43	49.40	48.58	47.76	47.40	47.13	46.58
MF(5X5)	48.82	48.15	47.50	46.91	46.61	46.34	45.98
MF(8X8)	47.70	47.19	46.71	46.26	46.04	45.78	45.49
MF(10X10)	47.32	46.88	46.44	46.03	45.84	45.57	45.32

Table 3: Restoration result SNR of Salt & pepper

FILTER TYPE	NOISE VARIANCE(Speckle Noise)						
	.02	.04	.06	.08	.10	.12	.14
MF(3X3)	65.21	64.61	63.94	63.56	63.03	62.55	62.17
MF(5X5)	63.37	62.99	62.51	62.28	61.85	61.46	61.13
MF(8X8)	62.10	61.89	61.51	61.28	61.09	60.70	60.47
MF(10X10)	61.71	61.55	61.20	60.98	60.74	60.51	60.27

Table 4: Restoration result PSNR of Speckle Noise

FILTER TYPE	NOISE VARIANCE(Speckle Noise)						
	.02	.04	.06	.08	.10	.12	.14
MF(3X3)	.0195	.0224	.0262	.0285	.0323	.0360	.0394
MF(5X5)	.0298	.0326	.0364	.0384	.0424	.0464	.0500
MF(8X8)	.0400	.0420	.0458	.0484	.0512	.0544	.0582
MF(10X10)	.0437	.0454	.0493	.0518	.0547	.0577	.0610

Table 5: Restoration result MSE of Speckle Noise

FILTER TYPE	NOISE VARIANCE(Speckle Noise)						
	.02	.04	.06	.08	.10	.12	.14
MF(3X3)	51.05	50.43	49.82	49.45	48.91	48.49	48.15
MF(5X5)	49.20	48.81	48.39	48.17	47.73	47.40	47.11
MF(8X8)	47.94	47.71	47.40	47.17	46.90	46.70	46.45
MF(10X10)	47.55	47.37	47.08	46.87	46.62	46.45	46.25

Table 6: Restoration result SNR of Speckle Noise

FILTER TYPE	NOISE VARIANCE(Gaussian Noise)						
	.02	.04	.06	.08	.10	.12	.14
MF(3X3)	63.46	62.07	60.89	60.23	59.65	59.17	58.84
MF(5X5)	62.14	61.00	60.07	59.52	59.04	58.53	58.34
MF(8X8)	61.26	60.37	59.56	59.06	58.69	58.26	58.00
MF(10X10)	60.96	60.19	59.41	58.92	58.59	58.17	57.91

Table 7: Restoration result PSNR of Gaussian Noise

FILTER TYPE	NOISE VARIANCE(Gaussian Noise)						
	.02	.04	.06	.08	.10	.12	.14
MF(3X3)	.0292	.0403	.0529	.0615	.0703	.0786	.0851
MF(5X5)	.0396	.0515	.0638	.0726	.0809	.0910	.0952
MF(8X8)	.0486	.0596	.0717	.0806	.0878	.0968	.1029
MF(10X10)	.0518	.0622	.0743	.0831	.0899	.0989	.1050

Table 8: Restoration result MSE of Gaussian Noise

FILTER TYPE	NOISE VARIANCE(Gaussian Noise)						
	.02	.04	.06	.08	.10	.12	.14
MF(3X3)	49.51	48.29	47.24	46.77	46.24	45.98	45.64
MF(5X5)	48.19	47.22	46.43	46.05	45.63	45.35	45.16
MF(8X8)	47.30	46.51	45.92	45.59	45.28	45.08	44.82
MF(10X10)	47.02	46.41	45.77	45.46	45.18	44.99	44.73

Table 9: Restoration result SNR of Gaussian Noise

FILTER TYPE	NOISE VARIANCE(Salt & Peppers)						
	.02	.04	.06	.08	.10	.12	.14
MF(3X3)	.0229	.0295	.0366	.0456	.0504	.0545	.0636
MF(5X5)	.0331	.0394	.0470	.0555	.0604	.0653	.0731
MF(8X8)	.0429	.0491	.0563	.0644	.0689	.0745	.0818
MF(10X 10)	.0469	.0528	.0599	.0680	.0721	.0780	.0851

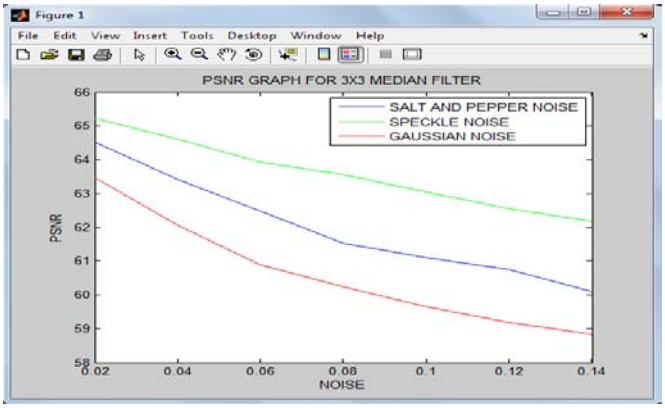


Figure 10.-PSNR Graph for 3x3 Median Filter

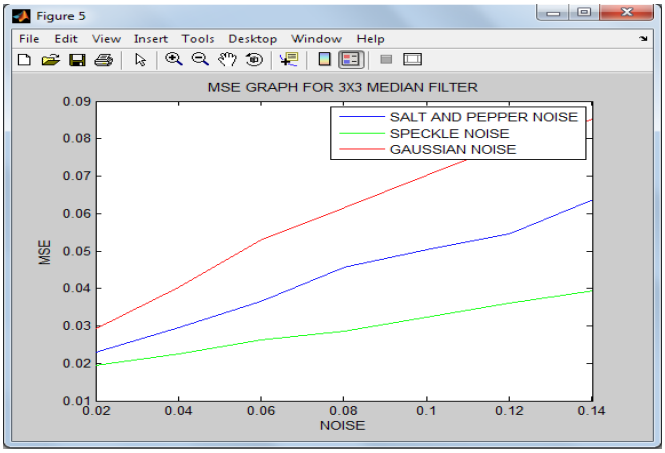


Figure 11.-MSE Graph for 3x3 Median Filter

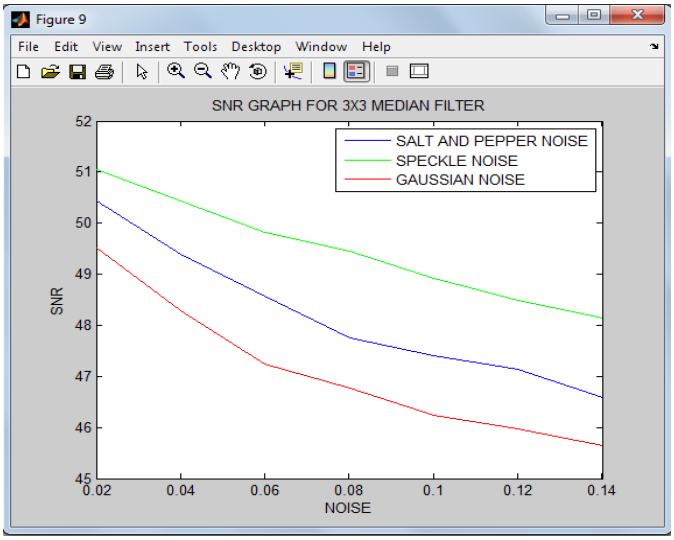


Figure 11.-SNR Graph for 3x3 Median Filter

VI. CONCLUSION

In this paper, we have seen the different noise source on median filter and experimental results tell that the median filter with 3x3 mask is more appropriate to remove salt and pepper and speckle noise but not good for Gaussian noise with noise variance between .02 to .14. The performance of median filter has been calculated by PSNR, MSE and SNR and we got performance of median filter is better for speckle noise for these particular biometrics image. The maximum performance of median filter has been measured for speckle noise on .02 noise variance respectively for salt and pepper and minimum performance for Gaussian noise which illustrated in the graphs with values in the table.

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