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IMAGE ENHANCEMENT FOR IMPULSE NOISE REDUCTION ON IMAGES USING VARIOUS FILTERS

S. Gopinathan [1] and S.Poornima [2]

[1] Assistant Professor, Department of Computer Science, University of Madras, Chepauk, Chennai, India.
gnathans2002@gmail.com

[2] Research Scholar, Department of Computer Science, University of Madras, Chepauk, Chennai, India.
poornilbs@gmail.com

ABSTRACT

This study is focused on how to digital images are often corrupted by Impulse noise due to errors generated in noisy sensor. The errors that occur in the process of Filters by sensor. In order to remove impulse noise and enhance the image quality. The median filter has been studied and the inverse filter has been proposed. This method removes or effectively suppresses the impulse noise in the image whiles preserving the image edges information and enhancing the image quality. The proposed method is a spatial domain approach and uses the overlapping window to filter the signal based on the selection of an effective value per window.

The performance of the proposed effective Inverse filter has been evaluated in MATLAB (2012a) using a 3 × 3 fixed window for simulations on an image that has been subjected to various degrees of corruption with impulse noise. The results demonstrate the effectiveness of the proposed algorithm. The Signal-to-noise ratios of the filtered image using the various filtering techniques are computed quantitatively, to show the effectiveness and efficiency of the method of this work. The Signal-to-noise ratio (SNR) has been used to compare the performance of the proposed Inverse filtering algorithm with other digital median filtering algorithms.

Key words : Impulse Noise, Median Filtering, Ultrasound, SAR, CT, PET, MRI Images, SNR, PSNR.,MATLAB.

1. INTRODUCTION

Digital Image processing play an important role, both in daily-life applications such as satellite television, medical images such as magnetic resonance imaging, computer tomography as well as in areas of research and technology such as geographical information systems and astronomy. [1] Denoising of image is realized by way of image filtering which can be divided into spatial domain, frequency domain and wavelet domain. The most common spatial domain filtering has two kinds of linear filters and nonlinear filters. Linear filters include linear average filter, inverse gradient weighted filter. Nonlinear filter is mainly used by median filter to remove impulse noise. A threshold and filtering templates of median filter to determine impulse noise is key operation. Indeed to improve image processing for median filter of impulse noise [1].

Image degradation is generally caused by Gaussian noise and impulse noise. For example, images collected with a camera contain Gaussian noise due to the characteristics of physical devices and electronic systems and pictures taken contain pulses noise caused by the external environment interference [3].

1.1 TYPES OF NOISES

Image Noise is classified as Amplifier noise (Gaussian noise), Salt-and-pepper noise (Impulse noise), Shot noise and Speckle noise (Multiplicative noise).

A.AMPLIFIER NOISE (GAUSSIAN NOISE)

It is an idealized form of white noise, which is caused by random fluctuations in the signal . In color cameras where more amplification is used in the blue color channel than in the green or red channel, there can be more noise in the blue channel. Amplifier noise is a major part of the noise of an image sensor, that is, of the constant noise level in dark areas of the image.In Gaussian noise, each pixel in the image will be changed from its original value by a (usually) small amount. A histogram, a plot of the amount of distortion. [14]

B.SALT-AND-PEPPER NOISE (IMPULSE NOISE)

Salt and pepper noise is sometimes called impulse noise or spike noise or random noise or independent noise. In salt and pepper noise (sparse light and dark disturbances), pixels in the image are very different in color or intensity unlike their surrounding pixels. Salt and pepper degradation can be caused by sharp and sudden disturbance in the image signal. Generally this type of noise will only affect a small number of image pixels. When viewed, the image contains dark and white dots, hence the term salt and pepper noise . [14]

C.SHOT NOISE

This noise is known as photon shot noise. Shot noise has a root mean- square value proportional to the square root of the image intensity, and the noises at different pixels are independent of one another. Shot noise follows a Poisson distribution, which is usually not very different from Gaussian. In addition to photon shot noise, there can be additional shot noise from the dark leakage current in the image sensor; this noise is otherwise known as "dark shot noise" or "dark-current shot noise".[14]

D. SPECKLE NOISE (MULTIPLICATIVE NOISE)

While Gaussian noise can be modeled by random values added to an image, speckle noise can be modeled by random values multiplied by pixel values hence it is also called multiplicative noise. Speckle noise is a major problem in some radar applications.[14]

1.2 IMPULSE NOISE

Impulse noise is a category of (acoustic) noise which includes unwanted, almost instantaneous (thus impulse-like) sharp sounds (clicks and pops). Noises of the kind are usually caused by electromagnetic interference, scratches on the recording disks, and ill synchronization in digital recording and communication. High levels of such a noise (200 + Decibels) may damage internal organs, while 180 Decibels are enough to destroy or damage human ears.[1]

TWO CATEGORY OF IMPULSE NOISE:

NOISE MODEL 1

Noise is modeled as salt-and-pepper or impulse noise. Pixels are randomly corrupted by two fixed external values, 0 and 255 (for 8-bit monochrome image), generated with the same probability. That is, for each image pixel at location (i,j) with intensity value (i,j), the corresponding pixel of the noisy image will be x(i,j) in which the probability density function of x(i,j)[8]

NOISE MODEL 2

Random Valued Impulse Noise (RVIN) will produce impulses whose gray level value lies within a predetermined range. For example, if gray level exceeds a LMAX value, it is a positive impulse (LMAX to 255); if gray level is less than LMIN, it is a negative impulse (0 to LMIN).[9]

MODEL OF NOISE REDUCTION

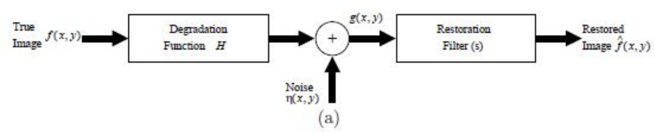


Figure1. Model of the image degradation/restoration process

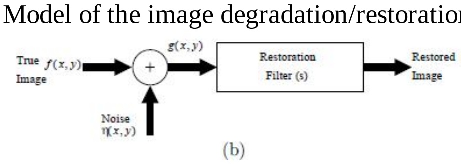


Figure 2. Model of Noise Removal process

2. EXISTING METHODOLOGY

Rafael C. Gonzalez and Richard E. Woods had discussed about the introduction to basic concepts of Digital Image Processing for beginners and also explained about the topics on Image Enhancement and Restoration, Image Denoising, Filter Types, etc., in an detailed manner.[1]

Rafael C. Gonzalez and Richard E. Woods had discussed about the topics of Digital Image Processing Using MATLAB and also provided the solutions to specialized problems in an detailed manner. [2]

S. Jayaraman, S.Esakkirajan and T.Veerakumar had discussed about the topics on Digital Image Processing including Image Denoising, Types of noise, Various types of filters, etc., in a detailed manner.[3]

E. Davies had discussed on the topics of advanced method compared with standard median filtering, the Adaptive Median Filter. Also discussed on various topics like Median filter, Mean filter Linear & non-linear filter, Image smoothing, Image enhancement, Impulse noise.etc., [4]

A. Marion had discussed on the topics of Inverse Filter, Adaptive Median Filter, Trimmed Average Filter, etc., This book also explained about different noise models in an efficient manner. [5]

A.K. Jain had discussed the fundamental Concepts of Digital Image Processing like Image Enhancement and Restoration, Image Denoising, Image Segmentation, Image Compression, etc., in an efficient manner. [6]

Brian D. Hahn and Daniel T. Valentine had presented MATLAB exercises for specialized problems and also presented many exercises for beginners to get familiarity with MATLAB. [7]

HanglinZenga, Yuan-zhongLiua, Yu-meiFana, ,XuefeiTangb was proposed an algorithm to improve image processing for impulse noise by median filter. The improved algorithm enhances the detection capability of the single element of an image. Impulse noise is removed by a method of improvement of choice of threshold and filtering templates of median filter. Experiment simulation showed that the method of image enhancement proposed is superior to the traditional method in effectively improving image degradation and image clarity.[8]

3. PROPOSED METHODOLOGY

INVERSE FILTER:

The inverse filtering is a restoration technique for deconvolution, i.e., when the image is blurred by a known low pass filter, it is possible to recover the image by inverse filtering or generalized inverse filtering. However, inverse filtering is very sensitive to additive noise. The approach of reducing one degradation at a time allows us to develop a restoration algorithm for each type of degradation and simply combine them. The Wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing. It removes the additive noise and inverts the blurring simultaneously.[10]

WIENER FILTER

The Wiener filtering is optimal in terms of the mean square error. In other words, it minimizes the overall mean square error in the process of inverse filtering and noise smoothing. The Wiener filtering is a linear estimation of the original image [14].

Also called Minimum Mean Square Error (MMSE) or Least-Square (LS) filtering.

$$H_{mmse}(w_1, w_2) = \frac{H^*(w_1, w_2)}{|H(w_1, w_2)|^2 + K}$$

Where, $K = \frac{\sigma_w^2}{\sigma_z^2}$

AVERAGE FILTER

The Average (mean) filter smooth's image data, thus eliminating noise. This filter performs spatial filtering on each individual pixel in an image using the grey level values in a square or rectangular window surrounding each pixel [3,5].

For example:a1 a2 a3 a4 a5 a6 3x3 filter window a7 a8 a9 The average filter computes the sum of all pixels in the filter window and then divides the sum by the number of pixels in the filter window:Filtered pixel = (a1 + a2 + a3 + a4 ... + a9) / 9

Mean filter, or average filter is windowed filter of linear class, that smoothes signal (image). The filter works as low-pass one. The basic idea behind filter is for any element of the signal (image) take an average across its neighborhood.[3,4]

Now let us see, how to “take an average across element's neighborhood”. The formula is simple — sum up elements and divide the sum by the number of elements. For instance, let us calculate an average for the case, depicted in

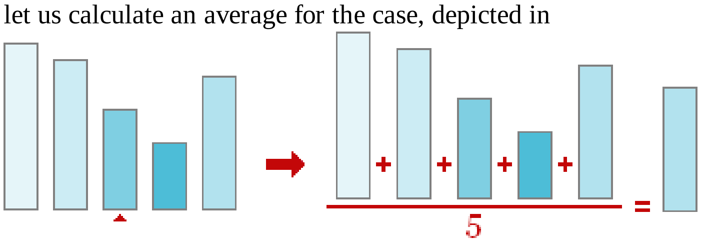


Figure 3. Taking an Average

Figure 4. 3×3 averaging kernel often used in mean filtering

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

ALGORITHM FOR FILTER SELECTION

STEP 1: Read the input image

STEP 2: Add Impulse Noise with standard deviation of different level.

STEP 3: Find the Noise using any suitable method.

STEP 4: Find the edges using any suitable method.

STEP 5: Set the window size5.

STEP 6: If the current center pixel is noise go to the step 7.

STEP 7: Calculate the center pixel value for each subset W1(Vertical) W2(Horizontal), W3 (Right Diagonal) and W4 (Left Diagonal)

STEP 8: Calculate the SNR and RMSE value.

STEP 9: Calculate the variance

STEP 10: The edge pixel is smoothness by the threshold and variance.

STEP 11: End.

DFD FOR PORPOSED FILTERS:

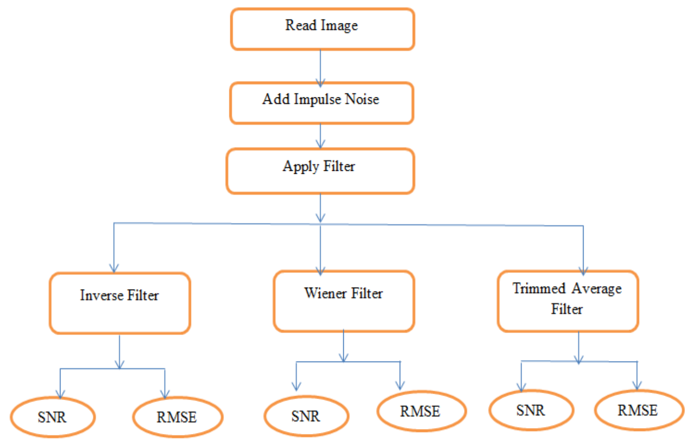


Figure 5. DFD for Proposed Filters

4. EXPERIMENTAL RESULTS

The result is to measure the performance of the enhancement system, we have tested the system with various images. The Impulse Noise added to the input image. Then we have applied the method for noise removal and enhancement. The results are reported for standard images like Lena, Cameraman, Pepper & fruits, Rice etc.,

In table 1, 2 and 3 we have shown the SNR and RMSE values corresponding to the selected standard images with impulse Noise of 0.05, 0.06, 0.07 and 0.08 for different enhancement methods like Median Filter, Adaptive Median Filter, Wiener Filter, Average Filter, Inverse Filter. The pictorial representations of these tables are shown in 5,6,7,8,9 and 10 respectively.

ESTIMATION OF STATISTICAL PARAMETERS

The parameters which are used in estimation of performance are Signal to Noise Ratio(SNR), Peak signal to noise ratio(PSNR), Structural Similarity Index(SSIM), Mean

Square Error(MSE), Root Mean Square Error(RMSE).[2,18][11]

A.ESTIMATION OF SNR

SNR compares the level of desired signal to the level of background noise. The higher the SNR, the lesser the noise in the image and vice versa.

$$SNR=10\log(\sigma_g 2/\sigma_e 2) \qquad (5)$$

Where, σ_g^2 is the variance of the original image and σ_e^2 is the variance of error between the original and image denoised with some filter. [2,18]

B.ESTIMATION OF RMSE

Mean square error (MSE) is given by

$$MSE=\Sigma^{N}_{i=j=1}[(i,)-F(i,j)]^2/N^2 \qquad (7)$$

Where, f is the original image F is the image denoised with some filter and N is the size of image. [2,18]

$$RMSE = \sqrt{MSE} \qquad (8)$$

Given below are the ultra scan noisy images and noise free image. Similar is the case for other images with σ = 0.02, 0.03, 0.04, 0.05, 0.06.[6]

Table 1: Comparative SNR Values of Standard images for different method: (Lena image)

Filters	SNR Value					
	0.05(noise)	0.06(noise)	0.07(noise)	0.08(noise)	0.09(noise)	0.10(noise)
Noise Image	24.1145dB	24.1148dB	24.1151dB	24.1154dB	24.1157dB	24.1158dB
Normal Median Filter	31.4638dB	30.9187dB	30.4965dB	30.0332dB	29.0315dB	29.3299dB
Adaptive Median Filter	32.6698dB	32.3643dB	32.1077dB	31.8114dB	31.6514dB	31.6252dB
Impulse Noise Median Filter	34.8883dB	34.922dB	34.9556dB	34.9993dB	35.0263dB	35.0563dB
Improved Median Filter	38.1243dB	38.094dB	38.0827dB	38.1084dB	38.0777dB	38.0773dB
Wiener Filter	46.8636dB	46.6451dB	47.0446dB	47.2648dB	47.4834dB	48.4146dB
Average Filter	66.5985dB	62.5373dB	57.7023dB	54.3239dB	50.3762dB	47.9141dB
Proposed (Inverse Filter)	49.6131dB	50.1998dB	51.4669dB	52.884dB	54.3053dB	55.2476dB

Figure 5: (Graph for all filters) SNR values of standard image

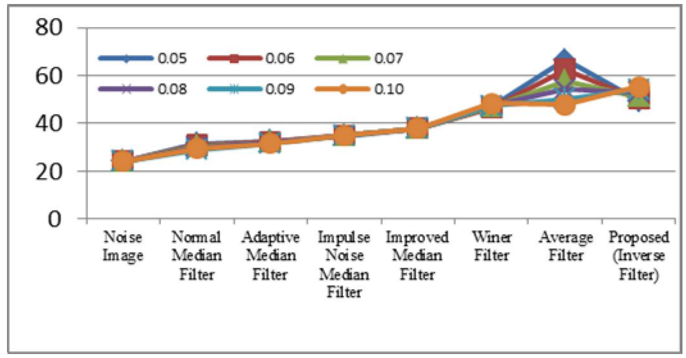


Table 2.Comparison of SNR values of Median and Inverse Filter: (Lena Image)

IMAGES	SNRVALUE					
	MEDIAN FILTER			INVERSE FILTER		
	0.5(ratio)	0.6(ratio)	0.7(ratio)	0.5(ratio)	0.6(ratio)	0.7(ratio)
	SNR	SNR	SNR	SNR	SNR	SNR
Lena	38.12	38.09	38.08	49.61	50.19	57.7
Cameraman	28.64	28.5	28.61	60.76	62.7	63.88
Pepper &Fruits	30.71	30.62	30.78	51.65	52.98	54.16
Rice	31.39	32.2	31.2	48.61	49.56	50.51

Figure 6. SNR values of standard images for Lena Image

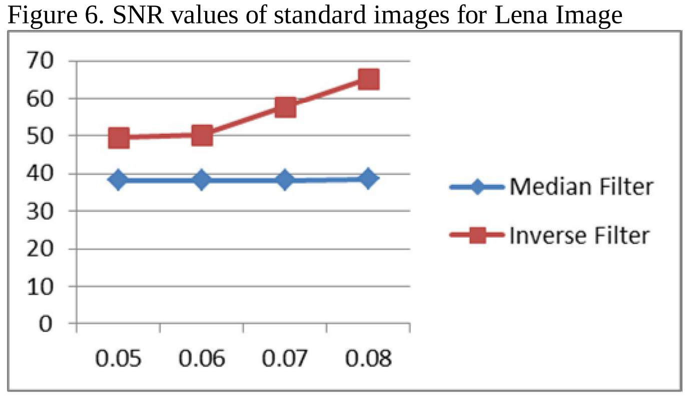
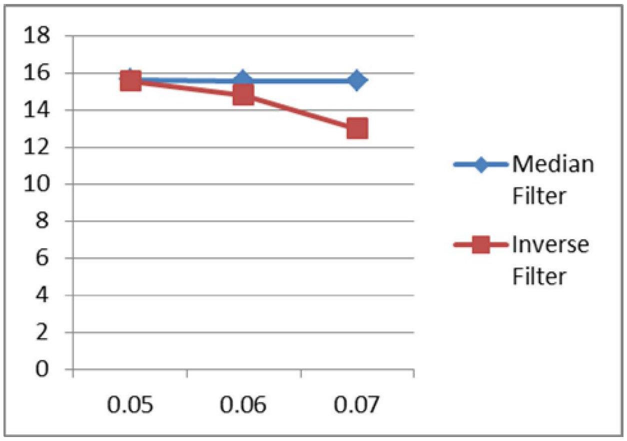


Table 2. Comparison of RMSE values of Median and Inverse Filter: (Lena Image):

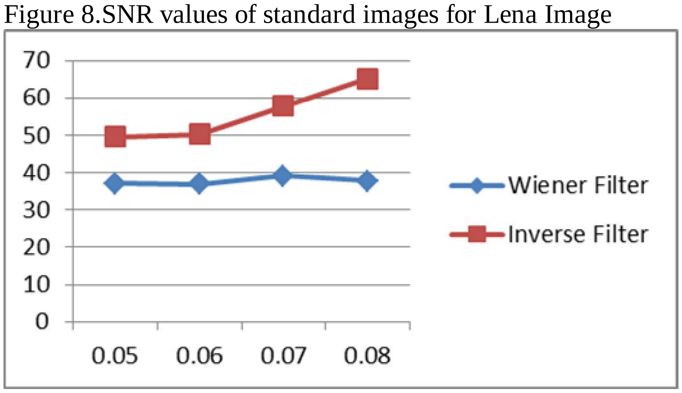
IMAGES	RMSE VALUE					
	MEDIAN FILTER			INVERSE FILTER		
	0.5	0.6	0.7	0.5	0.6	0.7
	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE
Lena	15.63	15.56	15.55	15.55	14.78	13.01
Cameraman	15.15	15.25	15.24	15.69	15.01	14.64
Pepper&Fruits	15.13	15.23	15.32	15.81	14.78	13.91
Rice	15.02	15.2	15.08	15.41	14.23	13.01

Figure 7.RMSE values of standard images for Lena Image



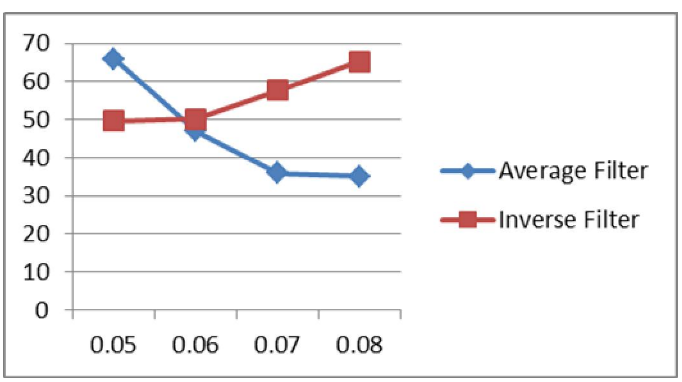
COMPARISON OF WIENER AND INVERSE FILTER: (LENA IMAGE)

Figure 8.SNR values of standard images for Lena Image



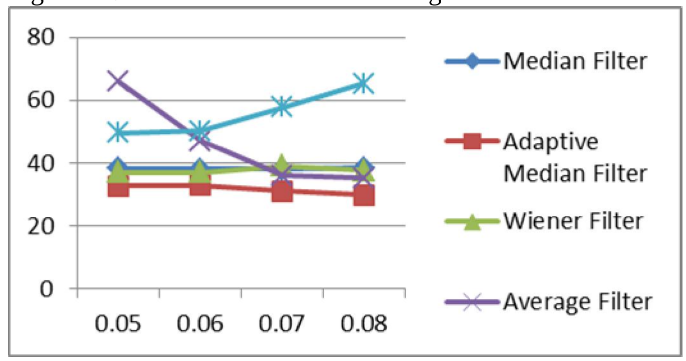
COMPARISON OF AVERAGE AND INVERSE FILTER: (LENA IMAGE)

Figure 9. SNR values of standard images for Lena Image



COMPARISON OF ALL FILTERS (MEDIAN FILTER, ADAPTIVE, WIENER FILTER, AVERAGE FILTER, INVERSE FILTER)

Figure 10. SNR values of standard images for all filters



My proposed method (Inverse) Filter value is better than all Filter values. So that inverse filter is gives best and degradation images and also image smoothing, sharping.

SCREENSHOTS

Existing System of Lena Image

Noise reduction by 0.05 ratios: (Normal Median filter)

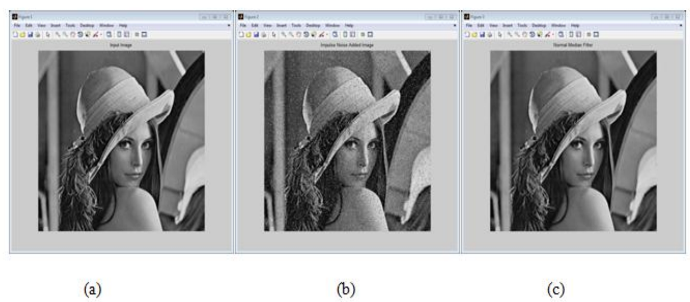


Figure 6.1.(a) Original Image (b) Impulse Noise added (c)Median filter

PSNR=31.4638Db

Noise reduction by 0.05 ratios: (Adaptive Median filter)

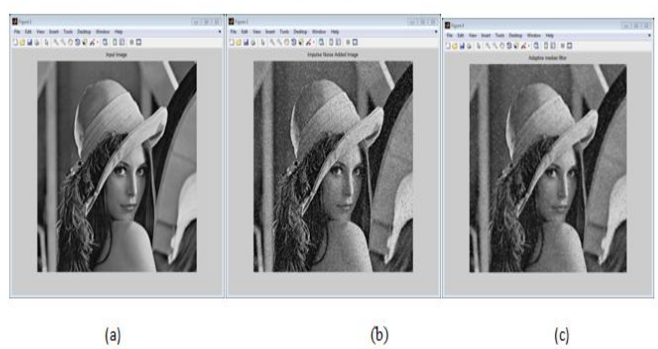
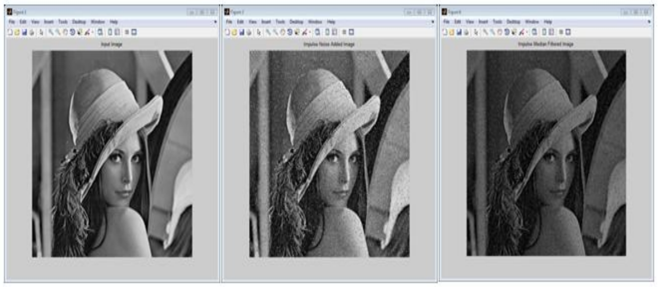


Figure 6.2 a)Original Image (b) Impulse Noise added (c) Adaptive Median filter

PSNR=32.6698Db

Noise reduction by 0.05 ratios: (Impulse Noise Median filter)

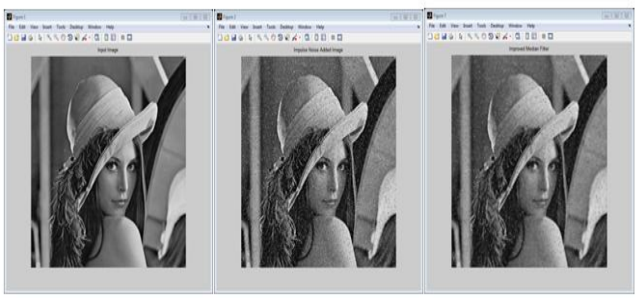


(a) (b) (c)

Figure 6.3 a) Original Image (b) Impulse Noise Added (c) Impulse Noise Median filter

SNR=34.8883dB

Noise reduction by 0.05 ratios: (Improved Median filter)

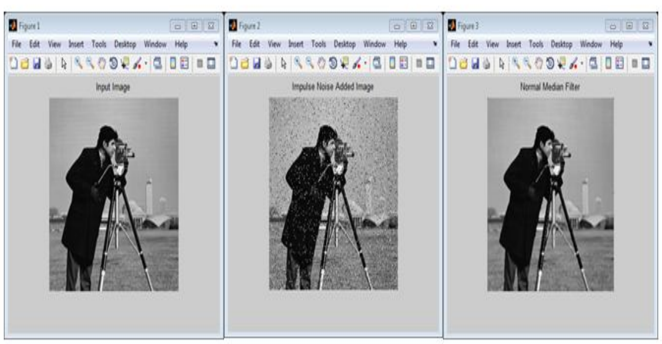


(a) (b) (c)

Figure 6.4 (a) Original Image (b) Impulse Noise added (c) Improved Median filter

SNR=38.1234dB

Noise reduction by 0.05 ratios: (Normal Median filter)

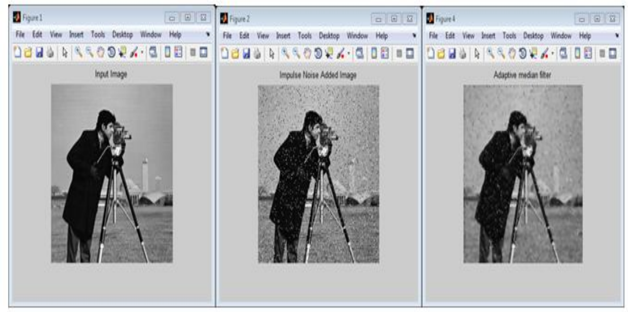


(a) (b) (c)

Figure 6.5 (a) Original Image (b) Impulse Noise Added (c) Normal Median Filter

SNR=28.64dB

Noise reduction by 0.05 ratios: (Adaptive Median filter)

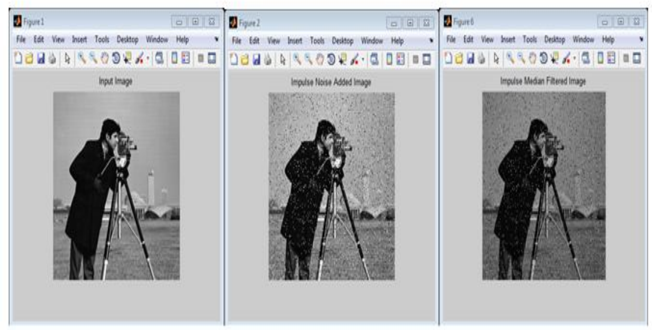


(a) (b) (c)

Figure 6.6 (a) Original Image (b) Impulse Noise Added (c) Enhanced Image

SNR=28.89dB

Noise reduction by 0.05 ratios: (Impulse Noise Median filter)

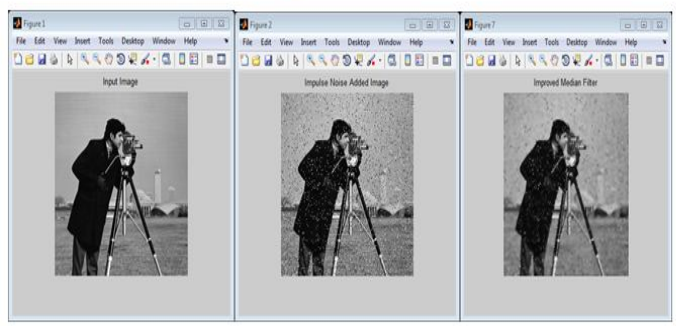


(a) (b) (c)

Figure 6.7 (a) Original Image (b) Noise Added (c) Enhanced Image

SNR=29.09Db

Noise reduction by 0.05 ratios: (Improved Median filter)

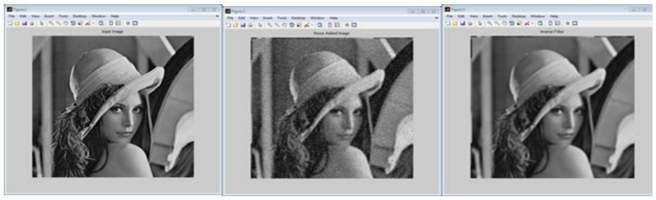


(a) (b) (c)

Figure 6.8 (a) input image (b) Noise added (c) Enhanced image

SNR=30.08dB

Noise reduction by 0.05 ratios: (inverse filter)

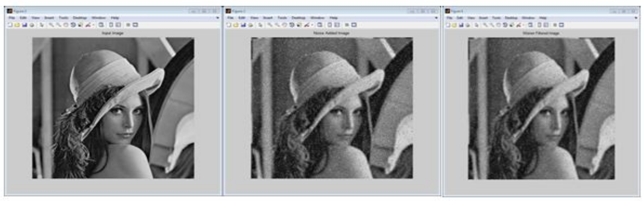


(a) (b) (c)

Figure 6.9 (a) Input Image (b) Noise added (c) Proposed Image

SNR=49.62dB

Noise reduction by 0.05 ratios: (Wiener filter)

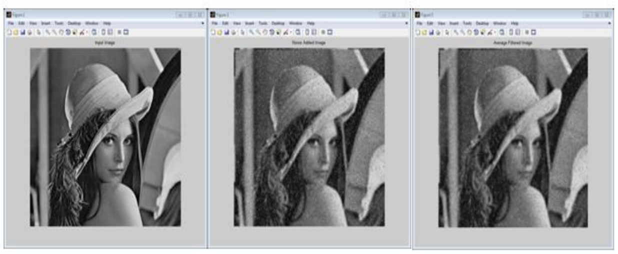


(a) (b) (c)

Figure 6.10 (a) Input Image (b) Noise Added (c) Wiener Filter

SNR=66.58dB

Noise reduction by 0.05 ratios: (Average filter)

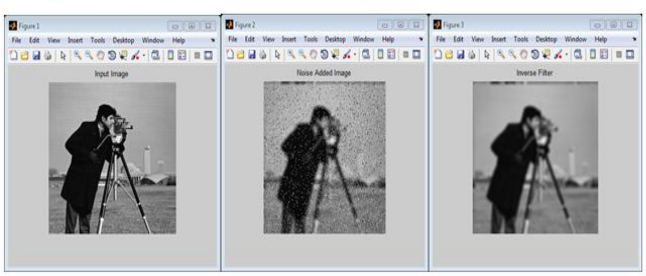


(a) (b) (c)

Figure 6.11 (a) Original Image (b) Noise Added (c) Average Filter

SNR=47.91dB

Noise reduction by 0.05 ratios: (inverse filter)

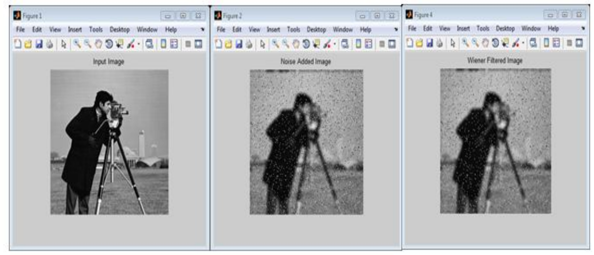


(a) (b) (c)

Figure 6.12 (a) Original Image (b) Noise Added(c) Inverse filter

SNR=60.76dB

Noise reduction by 0.05 ratios: (Wiener filter)

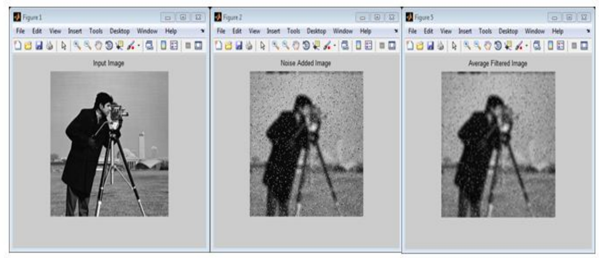


(a)(b) (c)

Figure 6.13 (a) Original Image (b) Noise Added (c) Wiener Filter

SNR=46.78dB

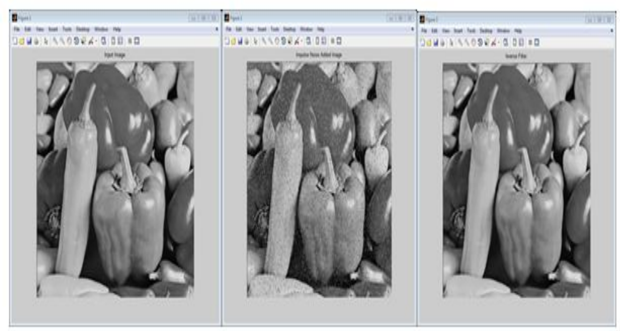
Noise reduction by 0.05 ratios: (Average filter)



(a) (b) (c)

Figure 6.14 (a) Original Image (b) Noise Image (c) Average Filter

Noise reduction by 0.05 ratios: (Inverse filter)

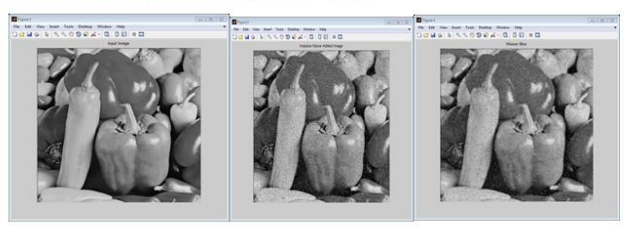


(a) (b) (c)

Figure 6.15 (a) Original Image (b) Noise added (c) Inverse Filter

SNR=51.65dB

Noise reduction by 0.05 ratios: (Wiener filter)



(a) (b) (c)

Figure 6.16(a) Original Image (b) Noise Added (c) Wiener Filter

SNR=46.86dB

Noise reduction by 0.05 ratios: (Average filter)

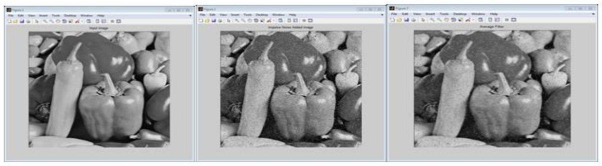


Figure 6.17 (a) Input Image (b) Noise Added (c) Average Filter

SNR=66.5985dB

Noise reduction by 0.05 ratios: (Inverse filter)

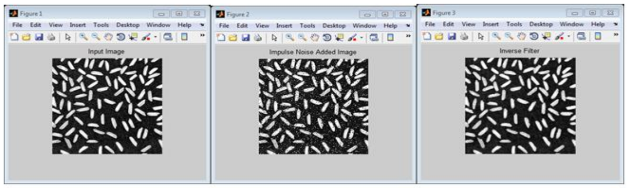


Figure 6.18 (a) Input Image (b) Noise Added (c) Proposed Filter

SNR=48.61dB

Noise reduction by 0.05 ratios: (Wiener filter)

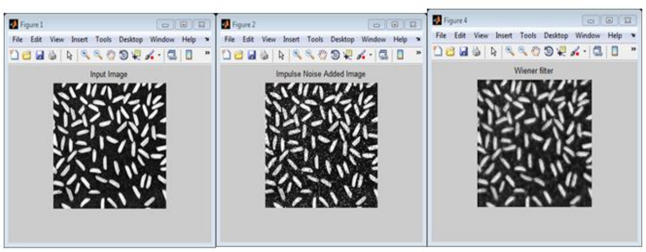


Figure 6.19 (a) Input Image (b) Noise Added (c) Wiener Filter

SNR=47.87dB

Noise reduction by 0.05 ratios: (Average filter)

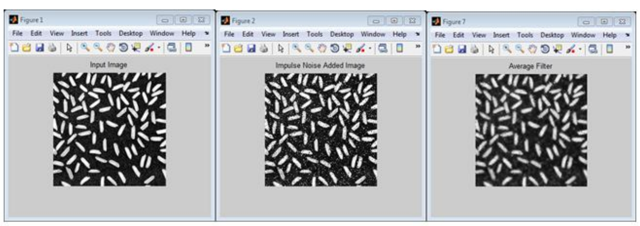


Figure 6.20 (a) Input Image (b) Noise Added (c) Average Filter

5. CONCLUSION

The Experimental result shows that the applied filters on gray-level-images can provide a better noise suppression with restoration of the original information, also retaining the edge patterns of standard images. Based on Experimental results the algorithm can provide a better performance.

A study can be made to find a fast algorithm. The filter parameters and threshold value for the parameter "p" are based largely on experimental result. There may be a systematic way to choose these parameters. In this work no measure is selected which has ability to measure the edge preserving value so in near future. Next we would like propose through wavelet techniques for filtering and enhancing this method.

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Dr.S.Gopinathan*working as a Assistant professor(SG) in the Department of Computer Science, University of Madras, Chennai, India. He have 14 years of Teaching Experience for Post Graduates in the field of Computer Science. He received his M.Sc.Computer Science from Bharathiar University and he received Ph.D. degree from University of Madras,Chennai,India. He has published number of papers. He have produced six M.Phil., scholars in the Department of Computer Science. He has also been serving as a panel member for Various competitive examinations. His Interested area of Research is Image Processing and its Applications.

S.Poornima**currently being as a Research scholar in University of Madras. She received the B.Sc. degree in Computer Science froms the University of Madras,Chennai,India,and the M.C.A. degree in Computer Application from the University of Madras,Chennai,India in 2011. She have done her M.Phil., Computer Science in University of Madras,Chennai. She is interested in doing research in the area of Image Processing.

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