

Performance Evaluation of Different Filters in Image Denoising for Different Noise

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ABSTRACT: Image denoising plays an important role in a wide range of applications such as image restoration, visual tracking, image registration, image segmentation and image classification. Noise acts as a distracting barrier and it degrades the resolution, image quality, image visuality and the object recognizing capability. There are no of existing methods for image denoising like wavelets, spatial, non spatial filters etc. In this work, Image denoising is performed by considering different types of noises (Salt & pepper, Gaussian, speckle and Poisson noise) and also analyzed the performance of different filters like median, wiener, average filters. Wiener filter is very effective for gaussian, speckle and poisson noise and Median filter is very effective for salt & pepper noise. PSNR (Peak signal noise ratio), MSE (mean square error), CC (Correlation coefficient) parameters are used to measure the performance of filters. Further the performance of different filters is evaluated by taking different types of noises. Further, it provides a framework for research work based on image denoising.

KEYWORDS: Wiener filter, Poisson noise, Gaussian noise, Speckle noise, Median filter, Salt & Peeper noise, Poisson noise, PSNR, MSE.

I. INTRODUCTION

Digital images are playing an important role in research and technology. Noise present in an image is a distracting artifact that degrades the quality and resolution of an image. Noise is an undesirable signal and random variation of brightness or color information. There are number of sources that arises the noise in original image such as image transmission, image acquisition [1]. Noise may be internal or external. External noise added [18] due to external factors like environmental conditions and internal noise that is generated within system like faulty switching etc. Sources of noise that are considered mainly are given below:

- By environmental conditions that affect the image sensors during image acquisition or transmission process.
- Noise can be introduced due to dust particles on scanner screen.
- Interferences in transmission channels introduce noise in an image during transmission process.
- Due to sensor temperature or insufficient light levels [10] [12].

II. IMAGE DENOISING

Image denoising is an important functional area of image processing. Denoising and deblurring are major tasks of image restoration. Image denoising lies on the objective side while image enhancement lies on the subjective side. There are number of existing Image denoising methods. Each method follows its own unique technique and each method has its own advantages and disadvantages. Some methods select denoising algorithm according to type and quantity of noise that are present in the image and others take account different factors like performance, edge discontinuities, computational time, and computational cost etc while performing denoising process [18]. A good denoising method preserves the features, edges and finer details of image while removing the noise. Traditionally, denoising performed using two types of models i.e. linear and non linear models. Linear Filters are used to remove the

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

certain kind of noise and blurring of sharp edges and eliminate lines and other finer details of image and when the signal dependent noise is present then it perform poorly. Mean and wiener filters are linear filters. The advantage of linear filters is speed but it cannot preserve the finer details of image. On the other hand, Non-linear filters are able to preserve the details of image. Non Linear filters have been developed to overcome the limitations of linear filters. Median filter is a non linear filter. Non Linear filters have good performance as compared to linear filters [1][9]. By definition of denoising problem, X is an original image and N is any type of noise and by adding N noise into an original image gets a Y noisy image as output.

$$Y = X + N$$

Our purpose is to denoise noisy image Y by using different filters i.e. Median filter, Average filter and Wiener filters [1].

III. DIFFERENT NOISE TYPES

There are various types of noise depending upon the disturbance that affects the image at different extents [12]. Image noise can be classified as [18]:

- Salt & Pepper Noise (Impulse Noise)
- Poisson Noise
- Speckle Noise
- Amplifier Noise (Gaussian noise)

A. Amplifier noise (Gaussian Noise):

The Standard model of amplifier noise is additive in nature and follow Gaussian distribution. The noise is independent at each pixel and signal intensity. In color cameras, blue channels produce more noise because blue color channels are more amplified than red or green channels. This type contains probability density function of normal distribution [5] [10] [18].

B. Salt & Pepper Noise (Impulse Noise):

Other terms used for this type of noise are impulse noise, spike noise, random noise or independent noise. Combination of black and white pixels are appears in the image. An image contains this type of noise consists two regions i.e. bright and dark regions. Bright regions contain dark pixels and dark regions contain bright pixels. Salt & Pepper noise introduced due to transmitted bit errors, dead pixels and analog to digital converter errors etc[5][10][16].

C. Poisson Noise:

Poisson noise or shot photon noise is a kind of electronic noise [18]. Poisson noise arise due to finite number of particles that carry energy i.e. electrons in an electronic circuit or number of photons sensed by sensor in an optical device is small enough to provide detectable statistical information [5] [12].

D. Speckle Noise

Speckle noise is a multiplicative noise. It is granular noise that degrades the quality of active radar and synthetic aperture radar (SAR) images [18]. It increases the mean grey level of local area. Speckle noise is due to coherent processing of backscattered signals from multiple distributed points. This type of noise is more serious in SAR because it causes the difficulties for image analysis or interpretations [5] [12].

IV. FILTERING TECHNIQUES

In Filtering techniques, various types of filters are used for removing the different noises from an image. The number of filters i.e. median filter, average filter and wiener filters. Each has its own advantages or disadvantages [9].

A. Median Filter

Median filter is type of non linear filter to remove the noise. Median filtering is performed by finding the median value the replacing each entry in the window with the pixel's median value [18]. If window has odd number of entries then

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Median is easy to calculate because it is just the middle value after all the entries are sorted numerically. There is more than one median if the window has an even number of entries. It is a robust filter. It provides the smoothness in image processing, signal processing and time series processing. It preserves the edges while removing the noise. It is particularly effective at removing salt and pepper type noise [16] [11].

B. Wiener Filter

Wiener filter is based on a statistical approach to minimize the mean square error between the estimated random process and the desired process. Wiener filter is used to filter out the noise from a corrupted signal. This filter is often applied in the frequency domain [18]. It is based on the assumption that the signal and noise processes are second-order stationary (in the random process sense). Another assumption is to have the knowledge of spectral properties of the original signal and noise. The Wiener filter is the MSE-optimal stationary linear filter for images degraded by additive noise and blurring [8] [11] [12].

C. Average Filter

Average or mean filter provides the smoothness by decreasing the intensity variations between the neighboring pixels [18]. It applies the mask over every pixel. To make a single pixel, each component of the pixels under the mask is averaged. Average filter is used to remove the grain noise from a photograph. The disadvantage of this filter is that it cannot preserve edges [7] [11].

V. PARAMETERS

A. Peak Signal to Noise Ratio

A high quality image has a small value of Peak Signal to Noise Ratio (PSNR). PSNR is defined as the ratio of signal power to noise power [18]. It basically obtains the gray value difference between the resulting image and the original image [12] [19].

$$PSNR = \left[10 \log \frac{255^2}{MSE} \right]$$

B. Mean Square Error

MSE is the sum over all squared value differences divided by image size [12] [19].

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

n = size (Input Image);

M = n (1);

N = n (2);

MSE = sum (sum ((Input Image - Reconstructed Image). ^2)) / (M*N).

C. Correlation Coefficient

A correlation coefficient is a coefficient that illustrates a quantitative measure of some type of correlation and dependence, meaning statistical relationships between two or more random variables or observed data values [16]. The correlation coefficient value lies between -1.0 to 1.0. If a calculated correlation is greater than 1.0 or less than -1.0, a mistake has been made. A correlation of -1.0 indicates a perfect negative correlation, while a correlation of 1.0 indicates a perfect positive correlation.

$$r = \frac{1}{n-1} \sum_{i=1}^n \left(\frac{x_i - \bar{x}}{s_x} \right) \left(\frac{y_i - \bar{y}}{s_y} \right)$$

where n is the number of pairs of data.

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VI. IMPLEMENTATION OF FILTERS & ANALYSIS

Here Lena image is considered as original image and salt & Peeper noise with variance 0.02 is added and calculated the parameters PSNR, MSE and CC for the Salt and Peeper noisy image and then applied Wiener filter, Average filter and Median filter to denoise the noisy image and recalculated the parameters PSNR, MSE and CC. It is observed from the calculated parameters that Median filter is better for all Salt & Pepper noise after denoising is better than Average filter and Wiener filter. Similarly Poisson noise, Gaussian noise and Speckle noise are added and calculated the parameters PSNR and MSE, CC for noisy images and then applied Wiener, Median and Average filters for denoising and recalculated the parameters after denoising to check the performance of filters. From results, it is observed that if higher the PSNR values and lower the MSE value then it gives better results, it is also observed that Wiener filter gives better results for Poisson, Speckle and Gaussian noise than Average and Median filters.

VII. SIMULATION RESULTS

Here original image is Lena image and four different types of noises like Gaussian noise, Salt & Pepper noise, Speckle and Poisson noise are added with variance 0.02. Further image is de-noised using wiener filter, median filter and average filter.

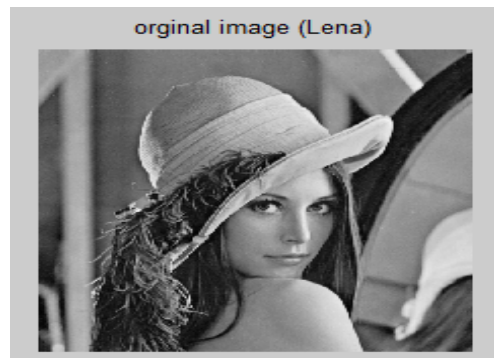


Fig.1. Original Lena Image



Fig. 2. Adding Gaussian noise with variance 0.02

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Fig.3. Denoised Gaussian Noisy image by Median Filter



Fig. 4 Denoised Gaussian noisy image by Average Filter



Fig. 5 Denoised Gaussian noisy image by Wiener Filter

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Fig.6 Adding Salt & Pepper noise with variance 0.02



Fig. 7. Denoised Salt & Pepper Noisy image by Median Filter



Fig.8. Denoised Salt & Pepper noisy image by Average Filter

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Fig.9. Denoised Salt & Pepper noisy image by Wiener Filter

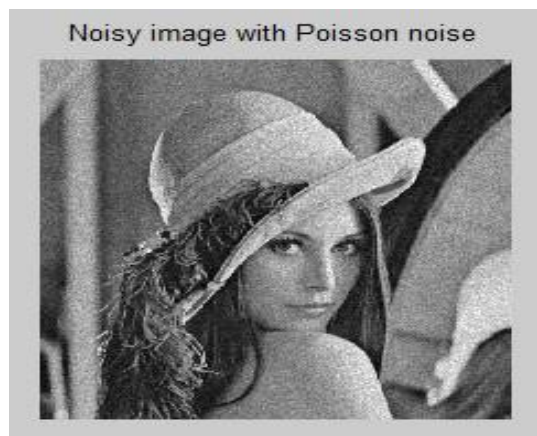


Fig. 10. Adding Poisson noise with variance 0.02



Fig. 11. Denoised Poisson noisy image by Median Filter

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Fig.12. Denoised Poisson noisy image by Average Filter



Fig. 13. Denoised Poisson noisy image by Wiener Filter



Fig.14. Adding Speckle noise with variance 0.02

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Fig. 15. Denoised Speckle Noise by Median Filter



Fig. 16. Denoised Speckle noise by Average Filter



Fig. 17. Denoised Speckle noise by Wiener Filter

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Table 1
Table showing Results of Median Filter on the basis of parameters MSE, PSNR, CC

Noise Type	Lena Image					
	PSNR		MSE		CC	
	<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>
Salt & Pepper	22.49	35.16	369.42	19.95	0.93	1.00
Gaussian	17.22	24.15	1241.76	251.85	0.80	0.95
Speckle	22.73	27.46	349.16	117.64	0.93	0.97
Poisson	27.24	31.69	123.82	44.39	0.97	0.99

Table 2
Table showing Results of Wiener Filter on the basis of parameters MSE, PSNR, CC

Noise Type	Lena Image					
	PSNR		MSE		CC	
	<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>
Salt & Pepper	22.39	28.74	377.99	87.67	0.92	0.98
Gaussian	17.22	24.38	1242.05	238.98	0.80	0.95
Speckle	22.74	23.68	348.94	280.92	0.93	0.94
Poisson	27.24	32.95	123.62	33.25	0.97	0.99

Table 3
Table showing Results of Average Filter on the basis of parameters MSE, PSNR, CC

Noise Type	Lena Image					
	PSNR		MSE		CC	
	<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>
Salt & Pepper	22.55	28.92	363.92	84.08	0.93	0.98
Gaussian	17.22	25.59	1243.35	180.96	0.80	0.96
Speckle	22.71	29.10	350.77	80.62	0.93	0.98
Poisson	27.24	30.75	123.64	55.16	0.97	0.99

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The results show graphically that the performance of median filter is better for all salt & pepper noise than average and wiener filter and wiener filter is better for all other types of noise. The graph shows the performance of different filters in a fig shown below.

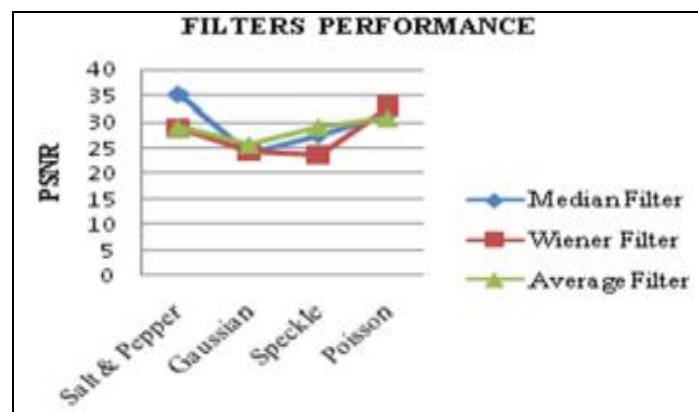


Fig. 18. Performance of different filters

VIII.CONCLUSION

This paper presents the performance of different filters for different types of noises. In this, Lena image (figure 1) in “png” format and added different types of noises (Gaussian noise, Salt & Pepper noise, speckle and Poisson noise) in the original image. (figure 2 to figure 5) and denoised all noisy images by different filters (figure 6 to figure 16) and results shown (Table 1 to Table 3)

- The performance of median filter for all salt & Pepper noise after denoising is better than average filter and wiener filter.
- The performance of wiener filter is better than average or median filter after denoising for all Poisson noise and speckle noise, Gaussian noise.

IX. SCOPE FOR FUTURE WORK

There are a number of areas exist which needs more improvement. One area is image denoising in which we would like to improve denoising with preserving finer image details as well as edges. The future work of research would be able to implement different filters in wavelet domain and applying the methods of filtering in both situations in which noise variance is known as well as unknown.

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