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ANALYSIS OF NOISE REDUCTION TECHNIQUES ON RANDOM IMAGES

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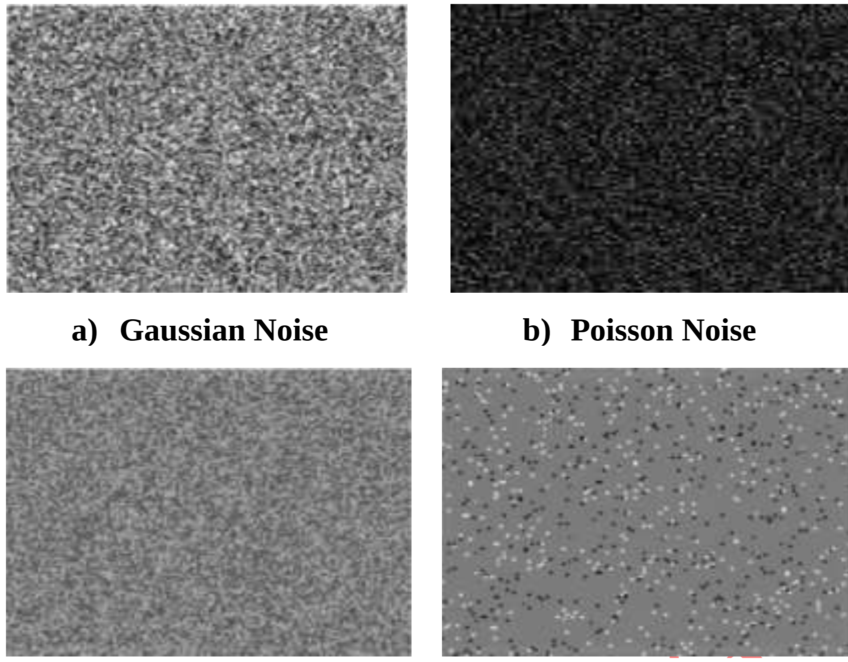
ABSTRACT

Digital Image Processing is evolving every day in the field of research. Newer Algorithms with accurate results is a boon to various domains including medicine, military, satellites and even daily life activities. The digital images we work with everyday are generally stored, transmitted and progressed in many ways which results in addition of noise to the image. Choosing a noise removal filter is application dependent so one needs to know the type of noise present in their images. This paper focuses on reviewing and analyzing existing noise reduction filters by implementing them on random images degraded by the noise. As a result of which we obtain better quality images. The paper also discusses about the types of noise present in the digital images.

Keywords: Digital Images, Filters, Noise.

I INTRODUCTION

Digital Images play a significant role in a number of fields constantly helping users working with different applications namely satellite television, MRI (Medical Resonance imaging), astronomy, foreign textiles, medical, document processing. In order to obtain high quality images it is necessary to apply noise reduction techniques on the images distorted with the noise. This step is considered as one of the primary step which has to be completed before performing high level processing steps. Few natural images are known to have an additive noise called Gaussian noise. Speckle noise is usually seen in ultrasound images and some other noises are poisson and salt-pepper noise. To represent the entire process in an equation v (i) = u (i) + n (i). Where u (i) is the true value of the image at the pixel i. n (i) is the noise value at the pixel i. v (i) is the observed value of the image at the pixel i. Hence removing the noise or reducing the intensity of the noise is a necessary step in many image processing applications. Although the search for error-free and efficient denoising algorithm is still going on, there are countable numbers of techniques in the field of image denoising which do the job commendably. The selective noise reduction techniques analyzed in this study such as Mean filter, Median filter, bilateral filter and Wiener filter have been found to be effective in reducing certain noises caught on images.



a) **Gaussian Noise** b) **Poisson Noise**

d) **Speckle Noise** c) **Salt-Pepper Noise**

Figure 1: Types of Noises found in nature

In the Figure 1, the signal disruption images are shown as they are found in the channel, the noises mentioned in this paper are Gaussian noise, Speckle noise, Poisson noise and Salt-Pepper noise. Gaussian noise is usually caused when there are unplanned variations in the signal, it can be found in the images which have been captured under high temperature. Poisson Noise which is popular by the name shot noise, is found in the images when the number of photons captured by the device is not enough to process a statistical information. Speckle noise is multiplicative noise, it can be processed by multiplying random pixel values of an image. Salt and pepper noise can be identified on the image comparatively easier because it is seen as black and white spots on the image, 0 for black (pepper) and 255 for white (salt).

II RELATED WORK

In paper [1], authors have identified a handful number of denoising methodologies to reduce the noise in the digital image. The paper covers enormous details while working with mean filter, median filter which were found to be successful in reducing the impulse type of noise from the images. They found that usage of wavelets – Discrete wavelets transform is appropriate for images corrupted with Gaussian data. Surprisingly, for images without the Gaussian data were found suitable while working with Independent Component Analysis. In order to protect the edges of the image from extreme smoothening the authors used Total variation model which did a complete justice in preserving the edges.

In paper [2], the authors have portrayed that even though there are better digital devices which works wonders on the images, there is always room for improvement in the field of image denoising. The studied four images – speckle, Gaussian, salt and pepper and poisson noise with the standard deviation of 0.01 were denoised using various filters. Although the Single value Decomposition (SVD), median filters and Gaussian filters reduced the noise, Morphological filters seems to do a better job than the other filters with respect to speckle, Gaussian and poisson noise. The drawback of Gaussian filter found was that it blurs the image to an extent. An image with salt and pepper noise is suitable for median filter. To acquire better results implement Single value decomposition following Gaussian filter.

In paper [3], the author not only provided high quality results but also enlightened the readers with the information about the various sources of noise in digital images. The noise can be added from film grain, due to the condition of the surroundings. With the help of various types of linear and non linear filters the author has provided graphical results and also analysis of the filters with their performance parameters results like peak to signal ratio (PSNR). It was evident that the filters were noise dependent, while median filter reduced the salt and pepper noise, speckle and poisson noise were reduced properly when wiener filter was used.

In paper [4], the author chose only two main stream filters, implemented and analyzed the results by comparing them to find the efficient filter among them as it was the main aim of this research. The focus was on removing the noise from a given signal which might have been developed while the transmission process of an image. The filters used were one of the basic filters – Mean filter and Median filter. While both the filters have their own advantages and limitations, Median filter outperformed mean filter in various areas. Continuing which, it is also seen that the median filter provided minimum mean square error (MSE) at different noise levels.

In paper [5], the authors explained the image denoising domain and the methodologies used in the field with the rich content in their paper. Working with different noise density values the filters performed better than expected. It was concluded that among the filters used, median filter should be given higher preference while reducing the salt and pepper noise in the digital images. The author also mentioned that in case the neural network pattern recognizer is trained with the denoised signals, then the rate of classification will determine by which factor the denoising methodologies should be measured.

III METHODOLOGY USED FOR NOISE REDUCTION IN IMAGES

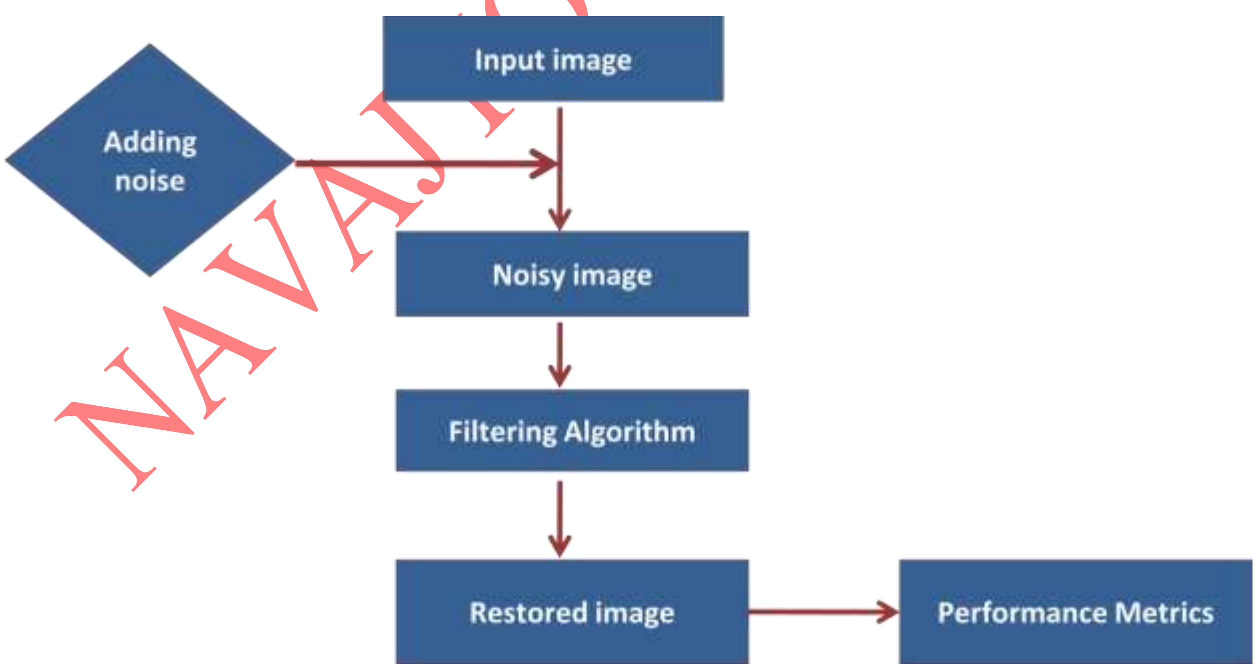


Figure 2: Existing denoising methodology in image processing

Figure 2 shows the uniformed steps that are followed in order to achieve the successful results.

The Steps are as follows:

Step-1: Input image(s) are taken from the dataset for filtering purposes.

Step-2: Selected filters are applied on the images consequently. Mean, Median, Wiener and Bilateral filters were chosen for this research.

Step-3: Each filtered image is evaluated based on obtained graphical results.

Step-4: Performance parameters should be applied to the obtained results for mathematical results. Peak noise to signal ratio, Mean square error and structure similarity index were chosen for this research.

Step-5: upon analysis it is identified which filter works better for the given noise.

IV IMPLEMENTATION

Experimental setup

This research was implemented using python programming language and with the help of several packages the better and accurate results were obtained. The packages included were Opencv, Matlab, Scikit and numpy. The operating system used was windows 7. The research was successfully concluded with two different input datasets.

Experimental Results

1. **Gaussian Noise** is commonly found in most of the images clicked by camera, it usually blurs the image. The original image, corrupted with Gaussian noise is displayed in Figure 3(a). From the graphical results it is identifiable that in order to remove Gaussian noise from the image, bilateral filter and wiener filter has been found to work better than other filters. The filtered results are displayed in the Figure 3(b).

Figure 3: a) Image with Gaussian Noise, density- 16 and b) Wiener, Mean, Median and Bilateral Filtered images.

Performance Metrics calculation:

	PSNR	MSE	SSIM
Mean Filter	26.62877 dB	141.31989 dB	0.40874
Median Filter	26.070923 dB	160.68967 dB	0.29717
Bilateral Filter	27.51930 dB	115.11970 dB	0.49044
Weiner Filter	25.423525 dB	186.52106 dB	0.95713

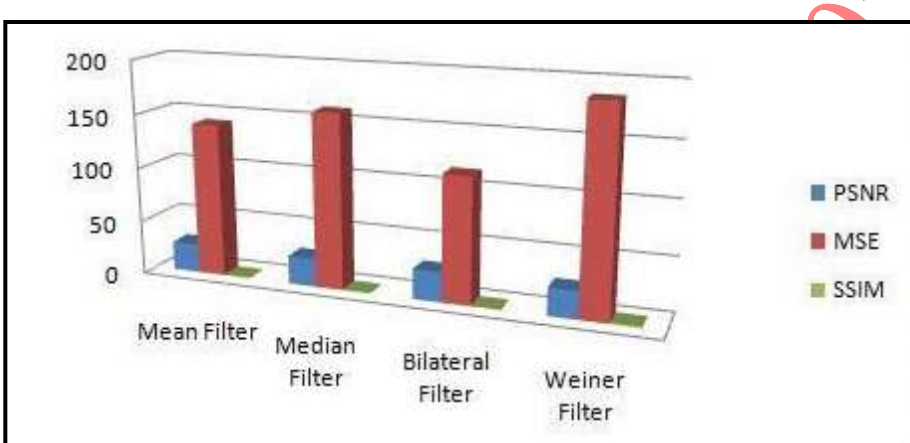


Figure 4: Performance parameter graph

The performance parameters peak signal to noise ratio (PSNR), Mean square error (MSE) and Structure similarity index (SSIM) have been calculated and displayed in Figure 4. From the calculations of performance metrics performed for this paper gave us the results that Bilateral filter produced high PSNR value and low MSE value with accurate SSIM value and wiener filter is seen to produce the second highest PSNR, lowest MSE and accurate SSIM. Hence, these two filters have been found effective in removing the Gaussian noise from the image.

2. **Poisson noise** is found in images when modeled by Poisson process, when photon count on the images is discrete and not divided properly. The noise density used for this image is 80 and Figure 4(a) shows the image corrupted with poisson noise. Viewing the graphical results displayed in Figure 4(b), it is evident that wiener filter worked better than other filters when used on images corrupted with poisson noise.

Figure 5: a) Image with Poisson Noise, density-80 and b) Weiner, Mean, Median and Bilateral filtered image

Performance Metrics calculation:

	PSNR	MSE	SSIM
Mean Filter	32.49260 dB	36.62859 dB	0.68300
Median Filter	31.58846 dB	45.10600 dB	0.59929
Bilateral Filter	31.26247 dB	48.62197 dB	0.55569
Weiner Filter	39.27268 dB	7.68796 dB	0.99600

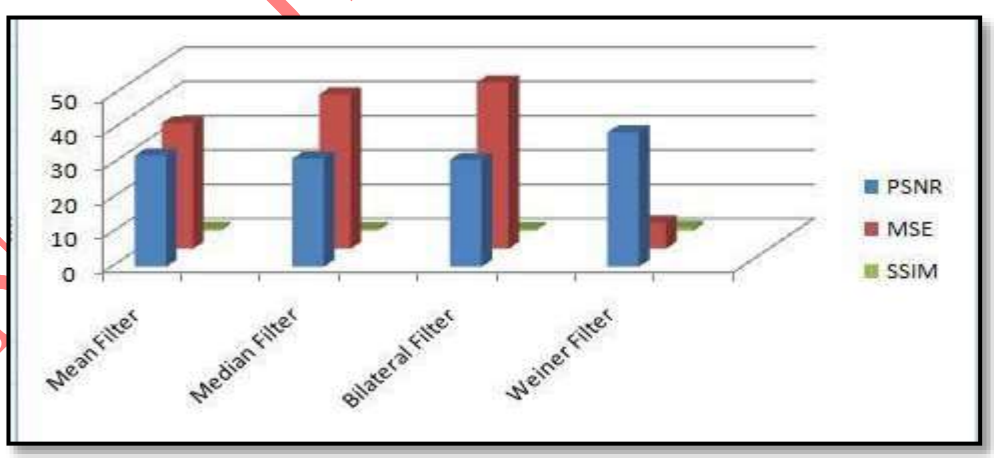


Figure 4: c) Performance parameter graph

The performance parameters peak signal to noise ratio (PSNR), Mean square error (MSE) and Structure similarity index (SSIM) have been calculated and the graph is designed according to the values mentioned in the table. The Figure 5 constitutes of a bar graph of the performance parameters of the four filters- Mean, median, bilateral and wiener. It is identified that the wiener filter produces images with high PSNR, low MSE and accurate SSIM making it efficient than other filters.

V CONCLUSION

In this paper, we discussed different filtering techniques for removing noises in color image. Furthermore, we presented and compared results for these filtering techniques. We have also studied what is a Noise in an image and the different types of noises available in an image. From the obtained implementation and mathematical results it is concluded that bilateral filter works best for denoising images with Gaussian noise, Weiner filter is proven best to denoise images with Poisson noise. Bilateral and wiener filter both works well for speckle noise. Median filter and bilateral filter works well for salt and pepper noise. Overall Bilateral filter is known be found efficient in removing the noise from the images. Performance of different denoising algorithms is measured by using quantitative performance measures such as peak signal-to-noise ratio (PSNR), Mean Square Error (MSE) and Structural similarity Index (SSIM). Since image denoising plays a crucial role in the field of digital image processing it is important to analyze enormous number of filtering techniques to obtain error-free and detailed results.

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