Performance Comparison of Median and Wiener Filter in Image De-noising

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ABSTRACT

Image filtering algorithms are applied on images to remove the different types of noise that are either present in the image during capturing or injected into the image during transmission. This paper deals with Performance Comparison of Median and Wiener Filters in Image de-noising for Gaussian noise, Salt & Pepper noise and Speckle noise.

Key words - Gaussian noise, Salt & Pepper noise, Speckle noise, Median filter, Wiener Filter.

I. INTRODUCTION

In several applications, it might be essential to analyze a given signal. The structure and features of the given signal may be better understood by transforming the data into another domain. There are several transforms available like the Fourier transform, Hilbert transform, wavelet transform, etc. However the Fourier transform gives only the frequency-amplitude representation of the raw signal. The time information is lost. So we cannot use the Fourier transform in applications which require both time as well as frequency information at the same time. The Short Time Fourier Transform (STFT) was developed to overcome this drawback [2].The following equation can be used to compute a STFT. It is different to the FT as it is computed for particular windows in time individually, rather than computing overall time (which can be alternatively thought of as an infinitely large window). x is the signal, and w is the window.

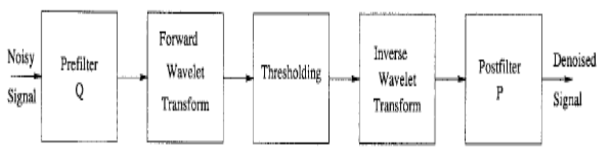


Fig: Diagram of wavelet based image De-noising

II. MEDIAN FILTER

The Median Filter is performed by taking the magnitude of all of the vectors within a mask and sorted according to the magnitudes. The pixel with the median magnitude is then used to replace the pixel studied. The Simple Median Filter has an advantage over the Mean filter since median of the data is taken instead of the mean of an image. The pixel with the median magnitude is then used to replace the pixel studied. The median of a set is more robust with respect to the presence of noise. The median filter is given by

$$\text{Median filter}(x_{1\ldots}x_N)=\text{Median}(\|x_1\|^2\ldots\ldots\|x_N\|^2)$$

III. WIENER FILTER

The goal of the Wiener filter is to filter out noise that has corrupted a signal. It is based on a statistical approach. Typical filters are designed for a desired frequency response. The Wiener filter approaches filtering from a different angle. One is assumed to have knowledge of the spectral properties of the original signal and the noise, and one seeks the LTI filter whose output would come as close to the original signal as possible [1]. Wiener filters are characterized by the following:

a. Assumption: signal and (additive) noise are stationary linear random processes with known spectral characteristics.
b. Requirement: the filter must be physically realizable, i.e. causal (this requirement can be dropped, resulting in a non-causal solution).
c. Performance criteria: minimum mean-square error.

5.1. Wiener Filter in the Fourier Domain

The Wiener filter is:

$$G(u,v) = \frac{H^*(u,v)\,P_s(u,v)}{|H(u,v)|^2 P_s(u,v)+P_n(u,v)}$$

Dividing through by $\mathbf{P_s}$ makes its behavior easier to explain:

$$G(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 + \frac{P_n(u,v)}{P_s(u,v)}}$$

where
H(u, v) = Degradation function
H*(u, v) = Complex conjugate of degradation function
Pn (u, v) = Power Spectral Density of Noise
Ps (u, v) = Power Spectral Density of un-degraded image

The term $\mathbf{P_n / P_s}$ can be interpreted as the reciprocal of the signal-to-noise ratio.

IV. IMAGE NOISE

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector [4]. Image noise is generally regarded as an undesirable by-product of image capture. Although these unwanted fluctuations became known as "noise" by analogy with unwanted sound they are inaudible and actually beneficial in some applications, such as dithering. The types of Noise are following:-

- Amplifier noise (Gaussian noise)
- Salt-and-pepper noise
- Speckle noise

Amplifier noise (Gaussian noise)

The standard model of amplifier noise is additive, Gaussian, independent at each pixel and independent of the signal intensity.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 "read noise" of an image sensor, that is, of the constant noise level in dark areas of the image[4].

Salt-and-pepper noise

An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions [4]. This type of noise can be caused by dead pixels, analog-to-digital converter errors, bit errors in transmission, etc.This can be eliminated in large part by using dark frame subtraction and by interpolating around dark/bright pixels.

Speckle noise

Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. Speckle noise in conventional radar results from random fluctuations in the return signal from an object that is no bigger than a single image-processing element. It increases the mean grey level of a local area. Speckle noise is caused by signals from elementary scatterers, the gravity-capillary ripples, and manifests as a pedestal image, beneath the image of the sea waves. One method, for example, employs multiple-look processing [6].

V. SIMULATION RESULTS

The Original Image is Flowertitlee image, adding three types of Noise (Gaussian noise, Speckle noise and Salt & Pepper noise) and De-noised image using Median filter and Wiener filter and comparisons among them.

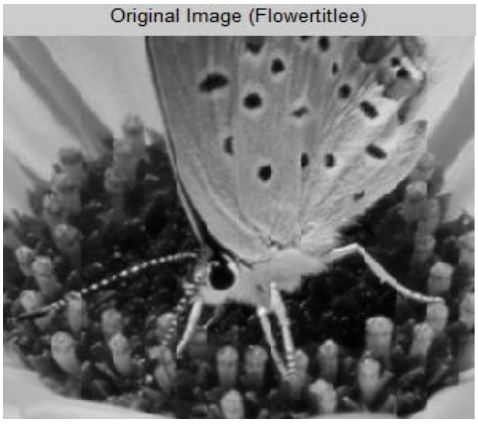


Figure 1

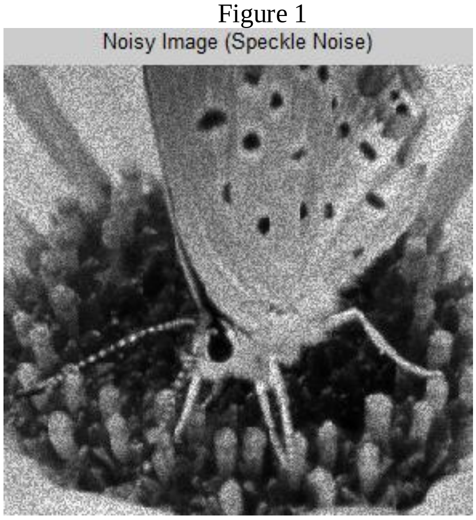


Fig 2.Noisy image with standard deviation (.025)

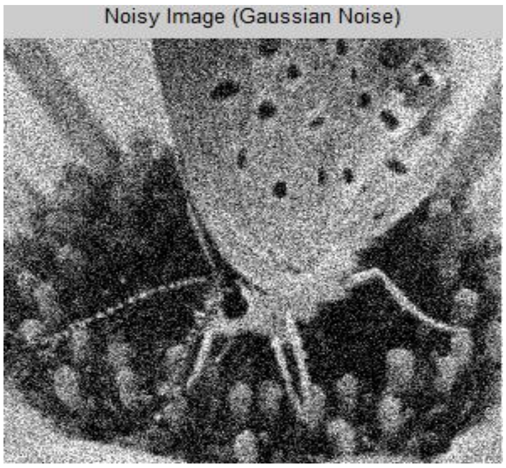


Fig 3.Noisy image with standard deviation(.025)

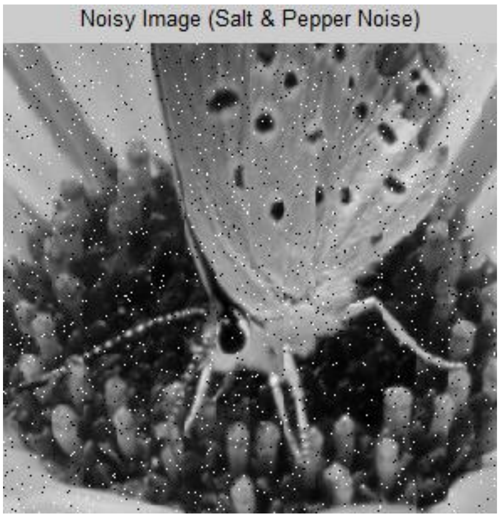


Fig 4. Noisy image with standard deviation (.025)

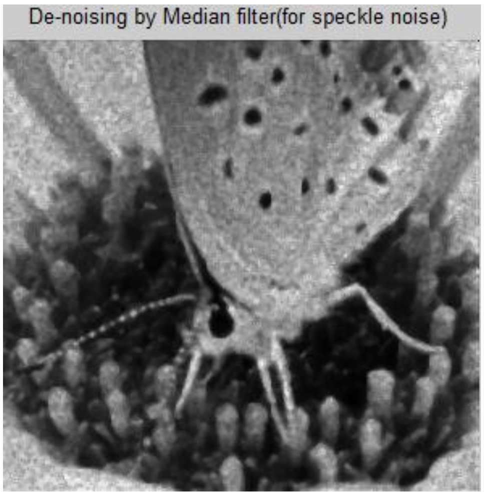


Figure 5

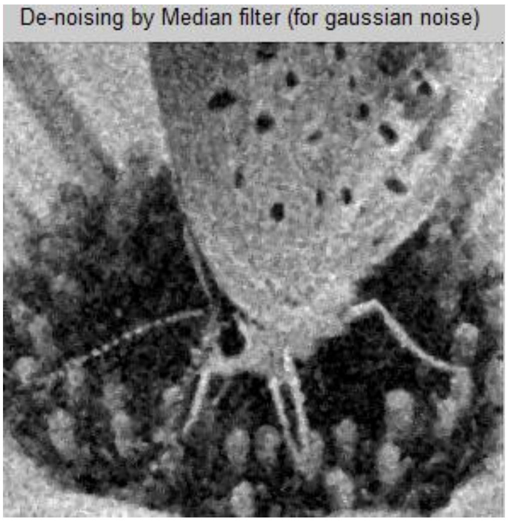


Figure 6

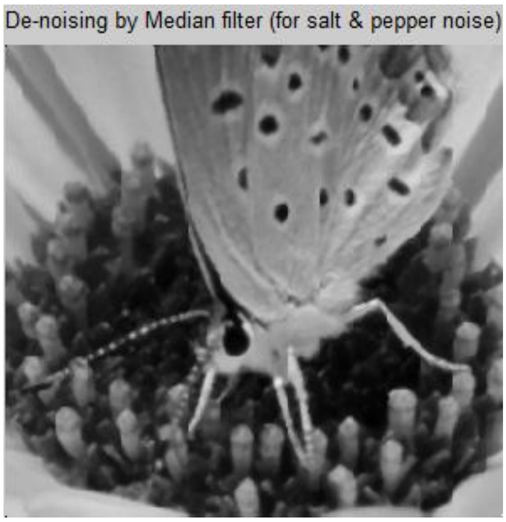


Figure 7

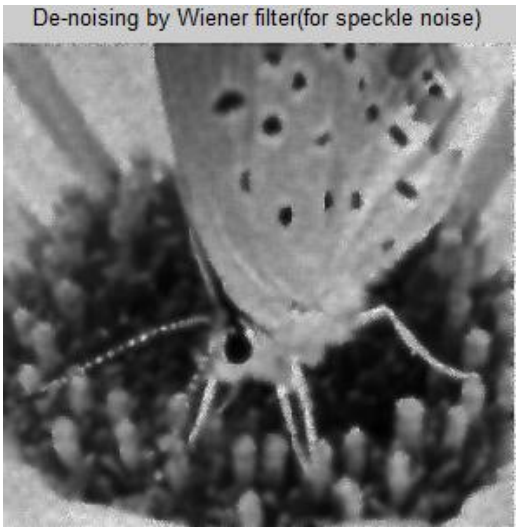


Figure 8

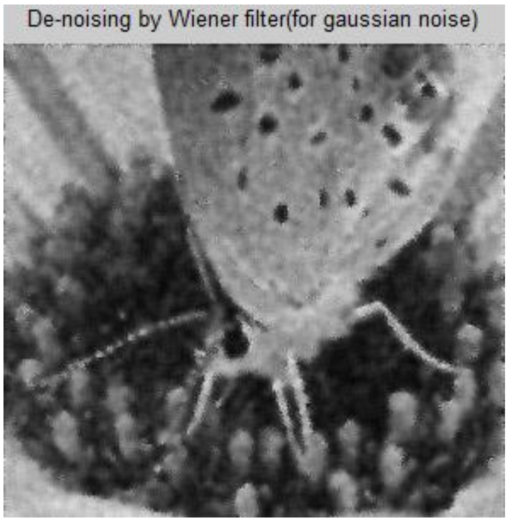


Figure 9

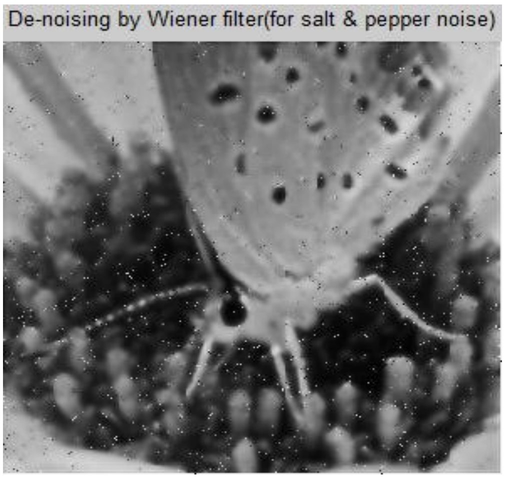
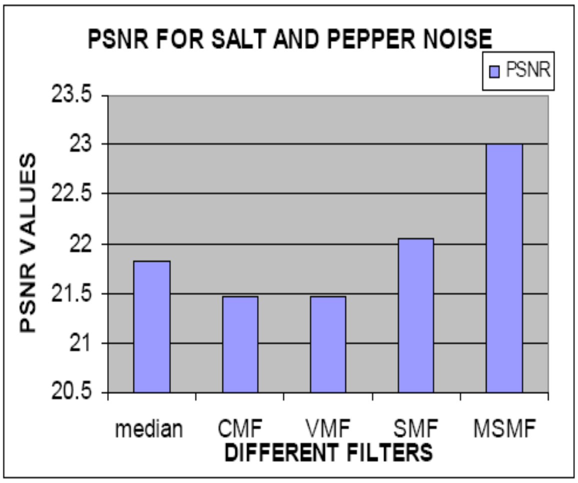
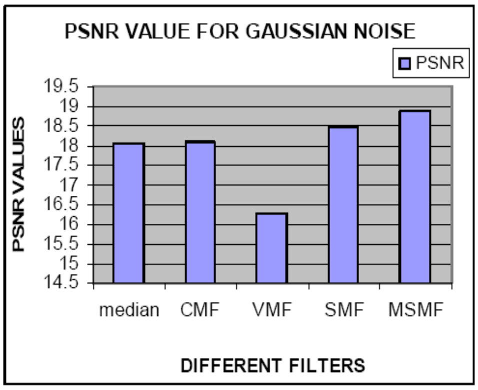


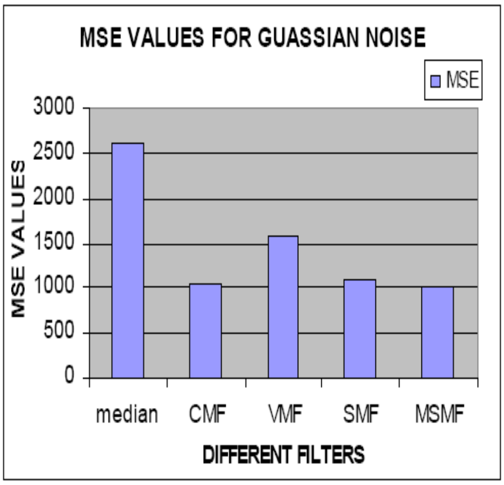
Figure 10



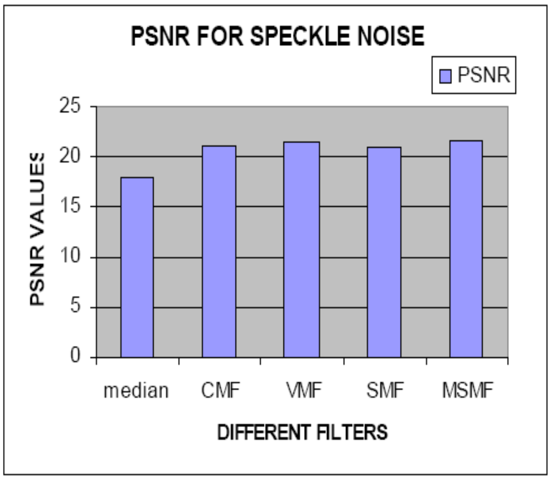
PSNR for salt & pepper noise



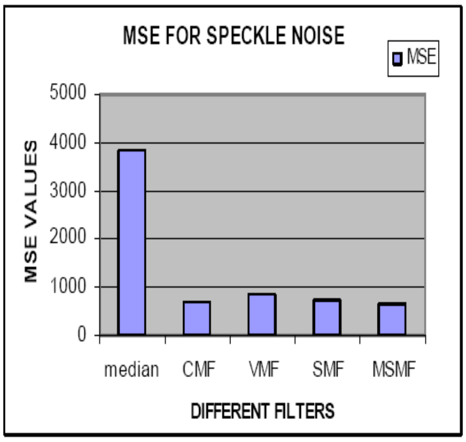
PSNR for Gaussian noise



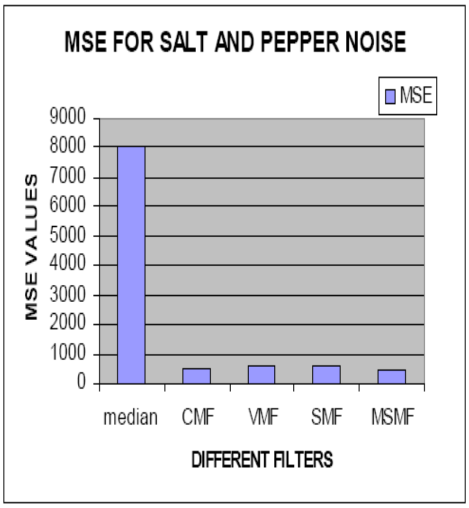
MSE for Gaussian noise



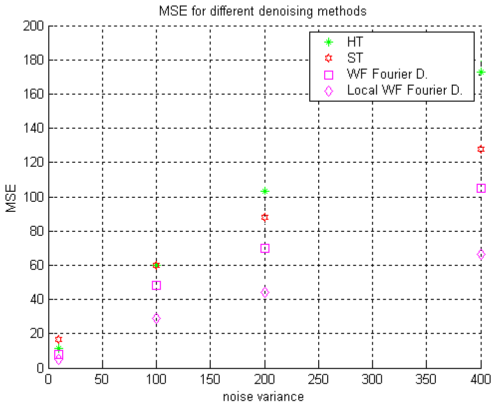
PSNR for Speckle noise



MSE for Speckle noise



MSE for Salt & Pepper noise



MSE for Wiener filter and thresholding (not use).

Table: Performance analysis of Median and Wiener filter for different noise

Filter Name	De-noising result for Speckle noise (%)	De-noising result for Gaussian noise (%)	De-noising result for Salt & Pepper noise (%)
Median Filter	70%	60%	95%
Wiener Filter	80%	70%	65%

VI. CONCLUSION

We used the Flowertitlee Image (figure 1) in "png" format ,adding three noise(Speckle, Gaussian and Salt & Pepper) with standard deviation(0.025). In these image (figure 2 to figure 4) ,De-noised all noisy images by all filters and conclude from the results (figure 5 to figure 10) that:

(a)The performance of the Wiener Filter after de-noising for Speckle and Gaussian noisy image is better than Median filter.

(b)The performance of the Median filter after de-noising for Salt & Pepper noisy image is better than Wiener filter.

VII. SCOPE FOR FUTURE WORK

There are a couple of areas which we would like to improve on. One area is in improving the de-noising along the edges as the method we used did not perform so well along the edges. The future work of research would be to implement Wiener Filter in Wavelet Domain.

VIII. REFERENCES

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