ISSN 2229-5518

A Comparative Study of Image Denoising Based on Different Noise Models and Different Filters

Shivakumar H S, Dhruvakumar T

Abstract— Now a day we want to take photographs everywhere, when we take a photograph in bad lighting condition the image will be corrupted by salt and pepper noise, which is an impulsive noise. Principal sources of Gaussian noise in digital images arise during acquisition. The noise affects human perception. The better human perception can be provided by using wiener and wavelet filters. The goal of the wiener filter is to compute a statistical estimate of the signal using a known signal to produce the estimate as an output.The wavelet filter decomposes the noisy image into different sub-bands where only the edges will be denoised by using thresholding techniques.Then the denoised subbands are recomposed with the approximation co-efficients to get better denoised image compared to wiener filtering. The image denoising helps in human perception and interpretation.

Index Terms— Image denoising, Noise models, Salt and Pepper noise, Gaussian noise, Wiener filter, Wavelet filter, Human perception and interpretation.

1 Introduction

THE image denoising is a thirst area in providing good human perception and interpretation. The image denoising is an important processing task, both as a process itself, and as a component in other processes. The noises like salt & pepper, Gaussian noise affects visual quality as well as human perception and interpretation. Very many ways to denoise an image or a set of data exists. The main property of a good imge denoising model is that it will remove noise while preserving edges.

Wiener filtration gives an estimate of the original uncorrupted image with minimal mean square error. The wavelet filter decomposes an image into approximation and detailed subbands, only the detailed co-efficients are denoised and then the denoised co-efficients are combined with the approximation co-efficients to get better denoised image compared to the wiener filtering image denoising.

2 Comparison of Denoising Methods

2.1 Salt and Pepper Noise

Salt and pepper noise is a form of noise sometimes seen onimages. It presents itself as sparsely occurring white and black pixels.

2.2 Gaussian noise

Gaussian noise is statistical noise having a probability density function equal to that of the normal distribution. In other words, the values that the noise can take on are Gaussian-distributed. The probability density function p of a Gaussian random variable z is given by

$$p\_G(z) = 1/(\sigma\sqrt{2\pi})\,(e\hat{}(-(x-\mu)\hat{}2/(2\sigma\hat{}2))) \quad (1)$$

Where z is the grey level, μ is the mean value and σ is the standard deviation.

2.3 Wiener filter and Wavelet filter

Wiener filter gives an estimate of the original un-corrupted image with minimal mean square error; the optimal estimate is in general a non-linear function of the corrupted image. The function can be written by,

$$f(u,v) = [\,[H(u,v)]\,\hat{}*/(\,[H(u,v)]\,\hat{}2\,[(S\_n(u,v))/sf(u,v)\,]\,)]G(u,v) \quad (2)$$

Where $H(u,v)$ is the degradation function, $H(u,v)]\ \hat{}*$ is its conjugate complex and $G(u,v)$ is the degraded image. Functions $sf(u,v)$ and $S\_n(u,v)$ are power spectra of the original image and the noise. Wiener filter assumes noise and power spectra of object a priori.

Wavelet domain filtering is divided into two distinct techniques one is called linear filtering where wiener filter is the generally used linear filter which yields most valuable outcomes in the wavelet domain filtering. It is used where data degradation can be modeled as a Gaussian process and accuracy criterion is mean square error. But this filtering provides visually inadequate than original degraded image and the second filtering method in wavelet domain is non-linear thresholding method where the threshold is estimated using the formula

$$T = \sqrt{(2\sigma\hat{}2\,M)} \quad (3),$$

Where $\sigma\hat{}2$ represents the noise variance estimated from the noisy image, T is the threshold value and M is the size of image used to select threshold. Threshold value should be choosen in such a way that it shouldn't be too high or too low. If the threshold value is too high we lose most of the information and if it's too low the image gets blurred. Hence the threshold value is estimated from the diagonal edge information which is the sub band due to wavelet decomposition.

2.4 Results

Salt & pepper noise	Noise density		0.05	0.10	0.15	0.20
	Wiener filter	MSE	0.08	0.09	0.10	0.11
		PSNR	4.40	3.88	3.43	3.03
	Wavelet filter	MSE	0.01	0.02	0.03	0.04
		PSNR	18.96	16.39	14.96	13.74

Table 1:- Mean squared error and peak signal to noise ratios for salt & pepper noise using wiener and wavelet filter.

ISSN 2229-5518

Gaussian noise	Noise variance		0.01	0.02	0.03	0.04
	Wiener filter	MSE	0.08	0.09	0.10	0.11
		PSNR	4.47	4.08	3.73	3.45
	Wavelet filter	MSE	0.008	0.014	0.021	0.027
		PSNR	20.89	18.22	16.70	15.64

Table 2:- Mean squared error and peak signal to noise ratios for Gaussian noise using wiener and wavelet filter.

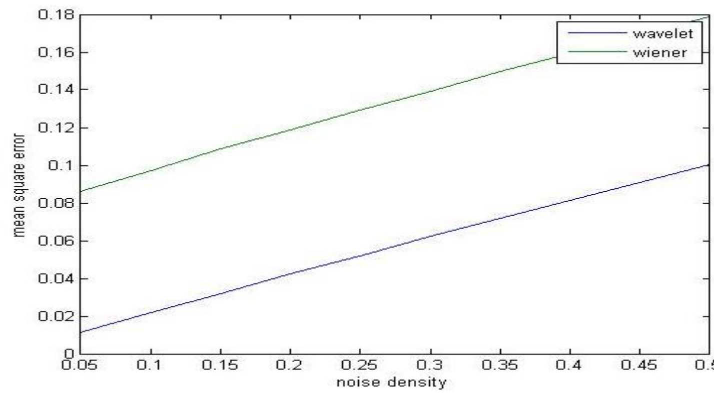
Figure 1:- Original image.

Figure 2:- An image corrupted by salt & pepper noise of density 0.05.

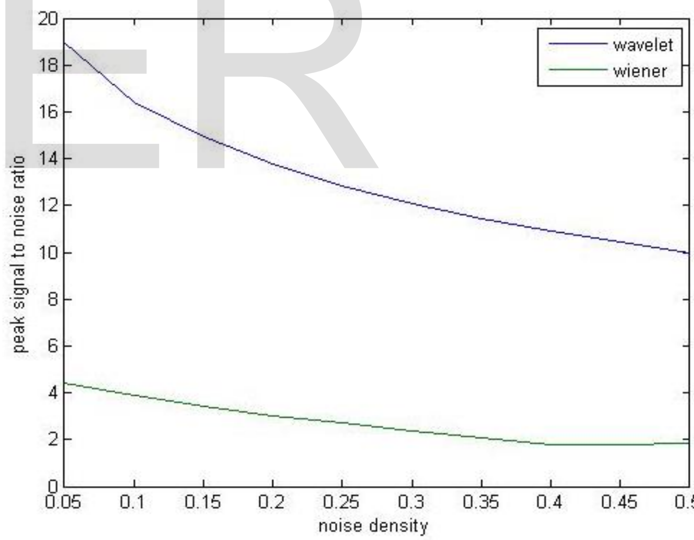
Figure 3:- Reconstructed image using wiener filter on the image corrupted by salt and pepper noise of density 0.05.

- *Shivakumar is currently pursuing masters degree program in Visvesvaraya Technological University, India, PH-8147501709. E-mail: shivakumar16lsp@gmail.com.*
- *Dhruvakumar is currently working as Asst.Professor in Siddaganga Institute of Technology, Tumakuru-572103, India, and PH-9448416732. E-*

Figure 4:- Reconstructed image using wavelet filter on the image corrupted by salt and pepper noise of density 0.05.



Graph 1:- Variation of mean squared error with salt & Pepper noise density for wavelet and wiener filter.

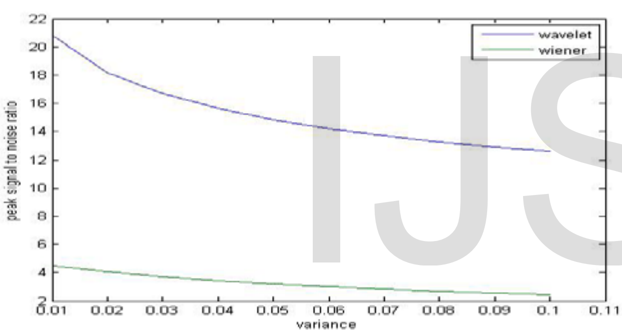


Graph 2:- Variation of peak signal to noise ratio with salt & pepper noise density for wavelet and wiener filter.

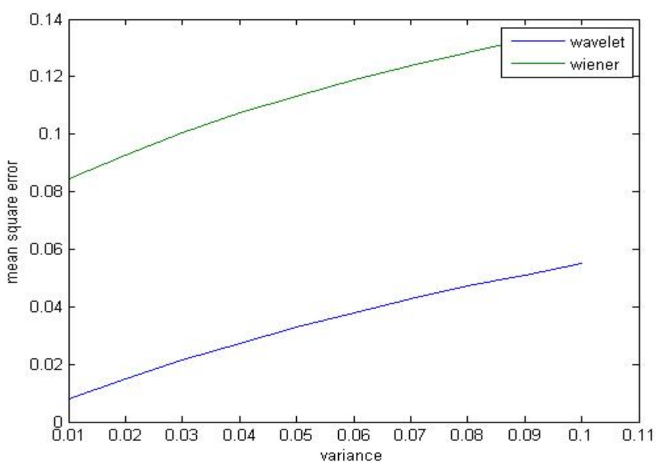
Figure 5:- An image corrupted by Gaussian noise of variance 0.01.

Figure 6:- Reconstructed image by the image which is corrupted by Gaussian noise of variance 0.01 using wavelet filter.

Figure 7:- Reconstructed image by the image which is corrupted by Gaussian noise of variance 0.01using wiener filter.



Graph 3:- Variation of peak signal to noise ratio with the



variance of Gaussian noise for wavelet and wiener filter.

Graph 4:- Variation of mean squared error with the variance of Gaussian noise for wavelet and wiener filter.

The above results are showing that the Gaussian noise can be effectively removed compared to salt & pepper noise. Wavelet filter gives better performance in terms of peak signal to noise ratio and mean squared error and also in visual quality compared to wiener filter for both salt & pepper noise and Gaussian noise.

2.6 Conclusion

Tests have been done on grey scale images of size $512 X 512$; wavelet filter gives better performance than wiener filter. Haar wavelet is used for testing. Still there are artifacts in the reconstructed images like blurring etc due to less directional selectivity of the transforms, the reconstruction can further be improved using highly directional transforms.

Acknowledgement

The authors gratefully acknowledge the helpful comments and suggestions of the reviewers that have improved the presentation.

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