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Noise Adaptive Fuzzy Switching Median Filters for Removing Gaussian Noise

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ABSTRACT

Recently, in all image processing systems, image restoration plays a major role and it forms the major part of image processing systems. Medical images such as brain Magnetic Resonance Imaging (MRI), ultrasound images of liver and kidney, retinal images and images of uterus images are often affected by various types of noises such as Gaussian noise and salt and pepper noise. All image restoration techniques attempts to remove various types of noises. This paper deals with various filters namely Mean Filter, Averaging Filter, Median Filter, Adaptive Median Filter, Adaptive Weighted Median Filter, Gabor Filter and Noise Adaptive Fuzzy Switching Median Filter (NAFSM) for removing salt and pepper noise. Among all the filters, NAFSM removes the Gaussian noise better than the other filters and the performance of all the filters are compared using metrics such as PSNR (Peak Signal to Noise Ratio), MSE (Mean Square Error), NAE (Normalized Absolute Error), Normalized Cross Correlation (NK), Average Difference (AD), Maximum Difference (MD), SC (Structural Content) and time elapsed to produce the denoised image.

Key words: Adaptive Weighted Median Filter • Averaging filter • Median filter • MSE (Mean Square Error) • NAE (Normalized Absolute Error) • NAFSM (Noise Adaptive Fuzzy Switching Median Filter, PSNR (Peak Signal to Noise Ratio) and SC (Structural Content)

1 Introduction

Generally, the image processing deals with processing of raw images into a suitable form which can be used for variety of applications. There are many domains in image processing such as image segmentation image enhancement, image restoration, image compression, image recognition and so on [1, 2]. Among all the domains, major part of image processing deals with image restoration. Images may be corrupted with noise during its acquisition and transmission and also due to blurring artifacts; an image may be corrupted with noise Blurring is a form of reduction in bandwidth. Also the may arise



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due to motion of the object itself [4]. Image restoration attempts these noises in the images while trying to as features as possible [5]. In the literature for removing restoration systems. Filtering may be used for noise reduction, interpolation and re-sampling of the images.

The choice of filter depends on the nature of the image be denoised and it also depends upon applications. Filtering can be generally done without detection and it can be done after the process of detection [6, 7]. One important issue to be considered while restoring the original image from the noisy image is that, balance between removing noise and preserving signal features must be considered [8]. This paper deals with removing one such type of noise namely salt and pepper noise. This paper deals with removal of Gaussian noise and salt [3]. Also the and pepper noise using various filters such as mean filter, noises or the average filter, median filter, adaptive median filter, motion of the adaptive weighted median filter, Gabor filter and NAFSM to remove to (Noise Adaptive Fuzzy Switching Median Filter). preserve as much There are Generally two types of noise models are present in any various filters available They are the additive noise model and multiplicative noise model.

2 Performance Metrics of Various Filters

The performance of all the filtering techniques is compared using performance evaluation metrics such as PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error) [11, 12]. The formula for MSE and PSNR are given by the following equations (3) and (4). The formula for other metrics is given in the equations (5) to (9).

$$MSE = \frac{1}{MN} \sum_{j=1}^m \sum_{k=1}^N (x_{j,k} - x'_{j,k})^2$$

$$PSNR = 10 \log \frac{(255)^2}{MSE}$$

Where $x_{j,k}$ represents the original image and $x'_{j,k}$ represents the restored image. The formula for Normalized Cross Correlation (NK) is given by

$$NK = \frac{\sum_{j=1}^M \sum_{k=1}^N x_{j,k} x'_{j,k}}{\sqrt{\sum_{j=1}^M \sum_{k=1}^N x_{j,k}^2 \sum_{j=1}^M \sum_{k=1}^N x'_{j,k}^2}}$$

Where, $x_{j,k}$ is the original image and $x'_{j,k}$ is the denoised image. The formula for Average Difference (AD) is given by,

$$AD = \frac{\sum_{j=1}^M \sum_{k=1}^N (x_{j,k} - x'_{j,k})}{MN}$$

Where, $x_{j,k}$ is the original image and $x'_{j,k}$ is the denoised image. The formula for Structural Content (SC) is given by,

$$SC = \frac{\sum_{j=1}^M \sum_{k=1}^N x_{j,k}^2}{\sum_{j=1}^M \sum_{k=1}^N x'_{j,k}^2}$$

Where, $x_{j,k}$ is the original image and $x'_{j,k}$ is the denoised image. The formula for Maximum



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Difference (MD) is given by,

$$MD = \text{Max}(x_{j,k} - x'_{j,k})$$

Where, x is the original image and x' is the denoised j,k j,k
Image.

The formula for Normalized Absolute Error (NAE) is given by

$$NAE = \frac{\sum_{j=1}^M \sum_{k=1}^N |x_{j,k} - x'_{j,k}|}{\sum_{j=1}^M \sum_{k=1}^N |x_{j,k}|}$$

3 Gaussian Noise Removal

All the filters are applied to the retinal image affected by the Gaussian noise. The result is simulated using MATLAB R2013a and the results are shown in the below figures. In Figure 1, (a) shows the original image, (b) shows the image added with Gaussian noise with a variance of about 0.09, (c) shows the denoised image using Mean Filter, (d) shows the denoised image using Average Filter, (e) shows the denoised image using Median Filter, (f) shows the denoised image using Adaptive Median Filter, (g) shows the denoised image using Adaptive Weighted Median Filter, (h) shows the denoised image using Gabor Filter and (i) shows the denoised image using Noise Adaptive Fuzzy Switching Median Filter (NAFSM). Salt and Pepper Noise Removal: All the filters are applied to the retinal image affected by salt and pepper noise. The result is simulated using MATLAB R2013a and the results are shown in the below figures. In Figure 2, (a) shows the original image, (b) shows the image added with salt and pepper noise with a variance of about 0.09, (c) shows the denoised image using mean filter, (d) shows the denoised image using average filter, (e) shows the denoised image using median filter, (f) shows the denoised image using adaptive median filter and (g) shows the denoised image using adaptive weighted median filter. Thus it is evident from the above Tables 1 and 2, that the proposed filter technique Noise Adaptive Fuzzy Switching Median Filter (NAFSM) denoises the image better than the mean filter, average filter median filter, adaptive median filter, adaptive weighted median filter and Gabor filter. It has lowest mean square error, highest peak signal to noise ratio, lowest normalized absolute error and a maximum structural content of 1.000. This clearly shows that, NAFSM produces best quality in the restored image from the noisy image. Also the NAFSM (Noise Adaptive Fuzzy Switching Median Filter) denoises the image in short span when compared to other filters. The Figures 3 to 9 show the comparison chart for PSNR, MSE, NAE, NK, SC and time elapsed respectively for both Gaussian noise and Salt and Pepper Noise removal in retinal image.



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Table 1: *Performance Comparison for Gaussian Noise*

S. No	Metrics	Mean Filter	Average Filter	Median Filter	Adaptive Median Filter	Adaptive Weighted Median Filter	Gabor Filter	Proposed Filter (NAFSM)
1	MSE	229.3256	227.5567	0.9203	0.5229	0.3279	0.3154	0.2275
2	PSNR	17.2058	24.5599	48.4914	50.9463	53.2458	53.8542	55.3865
3	NAE	0.0798	0.0640	0.0019	9.2233e04	0.7723e04	0.715e04	0.6932e04
4	SC	0.9752	0.9931	1.000	1.000	1.000	1.000	1.000
5	NK	0.9875	0.9899	0.9921	0.9956	0.9989	0.9991	0.9995
6	AD	258	225	198	97	85	65	59
7	MD	265	185	654	229	183	178	165
8	Time Elapsed in Seconds	5.2445	6.5887	4.6	2.7757	1.78	1.65	1.05

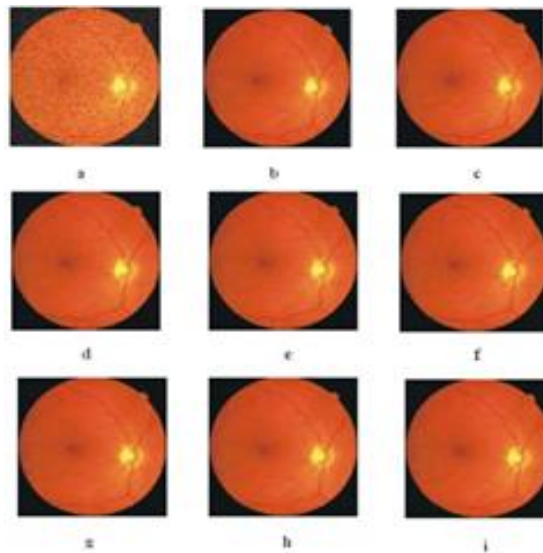


Figure 1: *Simulation results for removing Gaussian noise*



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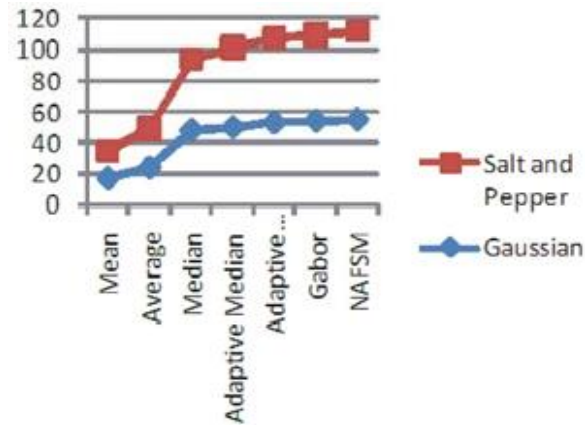


Figure 2: Comparison Graph of PSNR

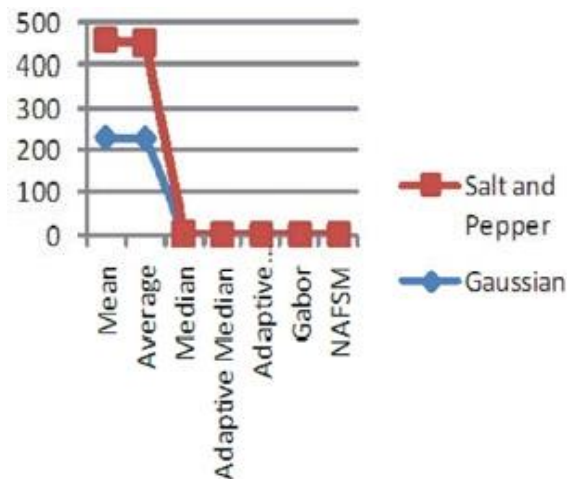


Figure 3: Comparison Graph of MSE

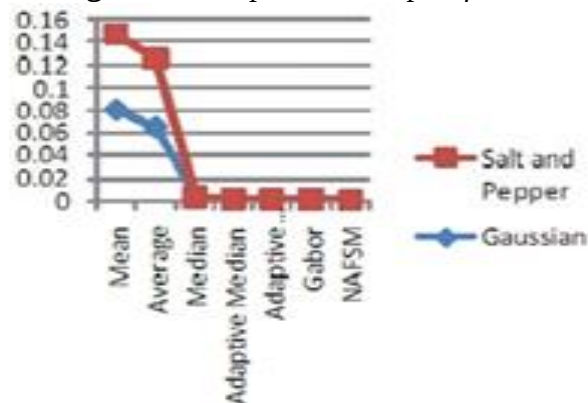


Figure 4: Comparison Graph of NAE



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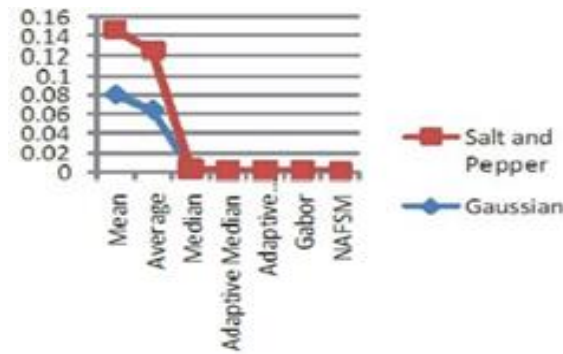


Figure 5: Comparison Graph of N

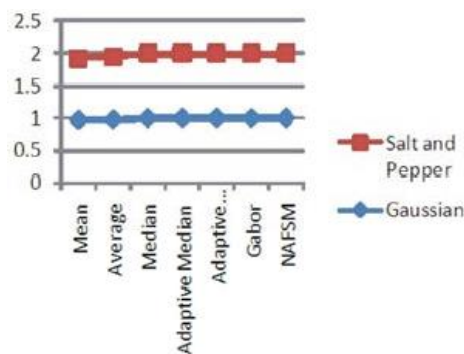


Figure 6: Comparison Graph of SC

4 Conclusion

Generally denoising medical image such as retinal images is a challenging task and this paper attempts to denoise the Gaussian noise and salt and pepper noise affected retinal images with the help of different filters. Among all the filters, NAFSM (Noise Adaptive Fuzzy Switching Median Filter) proves to be the best in terms of all performance metrics. The future enhancement of this paper includes implementing transforms such as wavelet and curvelet transform for removing not only Gaussian in retinal images but also all other types of noises including multiplicative noises such as speckle noise.

References

1. Gonzalez R.C; R.E. Woods, Year: 1992, "Digital Image Processing", Reading, Massachusetts: Addison-Wesley, pp. 716.
2. Cho T.S; C.L; Zitnick; N. Joshi; S.B. Kang; R. Szeliski; W.T. Freeman, Year: 2012, "Image restoration by matching gradient distributions", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol: 34, no: 4, pp. 683-694.



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3. Beck A; M. Teboulle, Year: 2009, "Fast gradient-based algorithms for constrained total variation image denoising and deblurring problems," IEEE Trans. Image Process, Vol: 18, no: 11, pp. 2419-2434.
4. Woods John W; J. Biemond, Year: 1984, "Comments on, A Model for Radar Images and Its Application to Adaptive Digital Filtering of Multiplicative Noise, in Pattern Analysis and Machine Intelligence," IEEE Transactions on, Vol: 6, no: 5, pp. 658-659.
5. Hore A; D. Ziou, Year: 2010, "Image Quality Metrics: PSNR vs. SSIM, in Pattern Recognition", (ICPR), 2010 20th International Conference On, 2366-2369: 23-26.
6. Buades A; B. Coll; J.M. Morel, Year: 2005, "A review of image denoising algorithms, with a new one," Multisc Model. Simulat, Vol: 4, no: 2, pp. 490 -530.