DENOISING USING SPECKLE NOISE REDUCTION FILTERS

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ABSTRACT

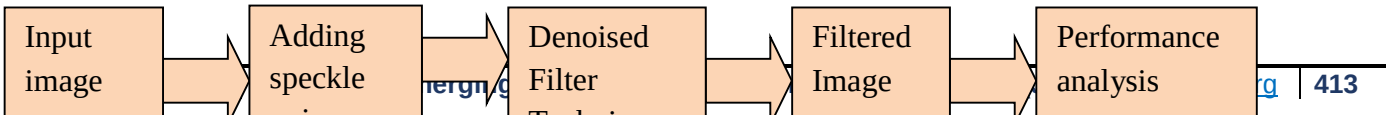
Noise reduction is often necessary and the first step to be taken before analyzing image data. The main goal of digital image processing is to remove various noise from all kinds of different images. It is therefore necessary that you have knowledge of the various noise in the image to determine the appropriate noise reduction algorithm. Noise is particularly affected by images taken from satellites, which reduces image quality. There are many reasons for this noise, such as salt, pepper, speckle, Gaussian. Because noise is very specific, many noise removal methods are designed for this purpose only. There are also some general methods for removing noise that have been slightly modified in order to remove noise spots. In this paper, filters reduce the spots are the frost filter, Gaussian filter smooth and the average filter which must be done based on the specific results for different noise conditions. This paper explains the techniques of the image noise reduction filter based on image quality standards at a different level of noise images.

***Keywords*: Salt and Pepper, Gaussian noise, Speckle noise, Frost filter, Gaussian smooth filter and Averaging filter**

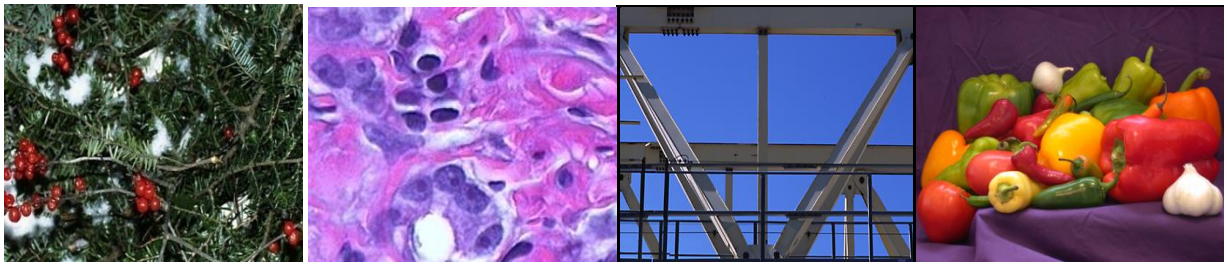
I. INTRODUCTION

Speckle Noise is the noise caused by the environmental conditions on the imaging sensor when the image is obtained. Color noise [1] is mostly detected in the case of medical images, active radar images and SAR images. Various researchers have conducted experiments to overcome this type of noise using different filtering techniques. In this paper, we provide a brief analysis of the various techniques used to reduce the noise of image spots taken from Matlab or any other source. Importance of applying advanced digital image processing techniques to improve quality by removing noise components in the image obtained for a better image [2].

Several methods are used to reduce the noise based on different mathematical models of this phenomenon. Here considered speckle noise and denoising process Frost filter, Gaussian smooth filter and Averaging filter are used. Using these filters, get a better output image than other filters. Finally, performance of denoising process techniques is compared with image quality metrics like PSNR, AD, NCC, IF, SC. This paper is further organized by Section II describes literature review. Section III discusses speckle reduction filter techniques. Section IV focus on the Quality metrics. Section V contains results and conclusion.



Initially, images are taken from the data base after applying different levels of speckle noise on the image. To remove the speckle noise different filtering techniques are used. By using noise reduction filters such as frost filter, Gaussian smooth filter and averaging filter are applied to different images. By comparing these reduction filters, we have to estimate which filter will give the better results based on image quality metrics.



(a) (b) (c) (d)

Figure1: Input images from Matlab Software (a) Image of Greens, (b) Image of Hestain, (c) Image of Gantry crane and (d) Image of Peppers

(a) (b) (c) (d)

Figure2: Speckle noise levels added to input images (a) Greens image with speckle noise 0.01, (b) Greens image with speckle noise 0.025, (c) Gantry crane image with speckle noise 0.01 and (d) Gantry crane image with speckle noise 0.025

(a) (b) (c) (d)

Figure3: Filtered images using frost filter (a) Filtered Greens image with speckle noise of 0.01, (b) Filtered Greens image with speckle noise of 0.025, (c) Filtered Gantry crane image with speckle noise of 0.01 and (d) Filtered Gantry crane image with speckle noise of 0.025

II. LITERATURE REVIEW

Yongjian Yu et.al proposed Speckle Reducing Anisotropic Diffusion. In this paper, Speckle reduction filters are Lee filter, Frost filter, anisotropic diffusion, SRAD to remove the noise. SRAD algorithm provides superior performance in comparison to the conventional anisotropic diffusion, the Enhanced Lee filter and the Enhanced Frost filter, in terms of smoothing uniform regions. [YongjianYu, Scott T. Acton-2002]. Milindkumar V. Sarode et.a1 proposed a study of speckle noise reduction filters like Frost filter, Kuan filter, Weiner filter, Bayes Threshold, The Performance of the Speckle noise Reduction model for Synthetic Aperture Radar (SAR) imagery is well as compared to other filters [Milindkumar V. Sarode , Prashant R. Deshmukh - 2011]

A.Stella et.al proposed Implementation of Proposed Despeckling Algorithm in Spatial Domain. In this paper, spatial domain filters are Enhanced Lee filter, Weiner filter, Total Variation filter, bilateral filter and Adaptive Lee filter used to reduce the speckle noise. Adaptive Lee filter gives more PSNR value than other filters. [A. Stella, Dr. Bhushan Trivedi, Dr. N.N.Jani – 2015]. Jyoti Jaybhay et.al proposed A Study of Speckle noise Reduction Filters like Mean filter, Median filter, Kuan filter, Frost filter, Enhanced Frost filter, Wiener filter and Gamma MAP filters.Mean and Median filters are good for removing high frequency noise but fail to preserve the edge details. Adaptive filters are more successful than filtering as itpreserves the details. [Jyoti Jaybhay and Rajveer Shastri-2015]. Richa Sohane, et.a1 proposed A study of speckle noise reduction filters like lee filter, frost filter, Median filter, Speckle Reduction Anisotropic Diffusion(SRAD), Perona-Malik's Anisotropic Diffusion(PMAD)filter, Speckle Reduction Bilateral Filter(SRBF) and Speckle Reduction filter based on soft threshold for Wavelet transform. In this speckle filter based on the wavelet transform gives good results. SRAD and PMAD Filters are improving the image quality. [Richa Sohane, Vandana Roy-2015]

Faouzi Benzarti et.al proposed Speckle Noise Reduction in Medical Ultrasound Images. In this paper, Speckle reduction filters are averaging homomorphic, Wiener filter, temporal averaging, median, adaptive speckle reduction and wavelet thresholding. Homomorphic transformation and diffusion filter gives good results. [Faouzi Benzarti, Hamid Amiri]. L.Gagnon, et.al proposed Speckle Filtering of SAR ImagesA Comparative Study between Complex-Wavelet-Based and Standard Filters. In this paper wavelet filter, Median,Lee, Kuan, Frost, Geometric, Kalman, Gamma, Oddy,AFS Filters are used to perform more efficiently on SAR images.Wavelet based filter is gives good result of figure of merit when compare with other filters.[L. Gagnon and A. Jouan]. Manoj Gupta et.al proposed Performance Enhancement and Analysis of filters in ultrasound image denoising. In this paper, Order statistics filter, Gaussian filter, Bilateral filter, Laplacian filter, Mean filter. PSNR value of mean filter is high when compared to other filters. [Manoj Gupta, Heena Taneja, Laxmi Chand-2018]

III. SPECKLE REDUCTION FILTERS

Frost Filter: Invented by Frost in 1982, is a linear filter used to remove multiple noise from pictures [3]. Frost filter is used to design an adaptive filter algorithm to reduce speckle noise in spatial domain and highly computational efficiency. This filter retains the important features of image at the edges. The Frost filter is an exponentially damped circularly symmetric filter that uses local statistics within individual filter windows. The filtered pixel is replaced with a calculated value based on the distance from the filter center, the damping factor, and the local variation. The Frost filter requires a damping factor (specify the extent of smoothing). The value of Damping Factor defines the extent of exponential damping. The smaller the value, the better the smoothing and filter performance [4]. After applying of the Frost filter, the denoised images show better sharpness at the edges.

$$DN=\sum_{n\times n} K\alpha e^{-\alpha|t|} \qquad (3.1)$$

Where

$$\alpha = \left(\frac{4}{n\sigma^2}\right)\left(\frac{\sigma^2}{\bar{I}^2}\right) \qquad (3.2)$$

K=Normalized constant

$\bar{\imath}$=Local Mean

σ=Local variance

$\bar{\sigma}$=Image coefficient of variation value

$$|t|=|X-X_0|+|Y-Y_0| \qquad (3.3)$$

n= moving Kernel size

Gaussian smooth filter: The Gaussian smoothing operator is a 2-D convolution operator that uses to `blur' images, remove details and noise. The idea of Gaussian smoothing is to use this 2-Dimensional distribution as a `diffusion point' function [5], and this is achieved by convolution. Because the image is stored as a set of discrete pixels we need to produce a separate Gaussian round approximation before we can perform the

convolution. It is not obvious how to pick the mask values to approximate Gaussian. One can use the Gaussian value in the middle of the pixel in the mask, but this is inaccurate because the Gaussian value differs non-linearly across pixels. We have combined the Gaussian value on the entire pixel (by collecting the Gaussian in 0.001 increments). It is similar to the average filter, but uses a different kernel that resembles the Gaussian shape ("bell-shape").

The product of two 1D Gaussian functions is given by

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}} \qquad (3.4)$$

The product of two 2D Gaussian functions is given by

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (3.5)$$

Averaging filter: It is simple and easy filter invented [6] by Pomalaza-Raez in 1984.The average filter is a simple spatial filter for the slider window that replaces the center value in the window with the average of all the pixel values in the window surrounding these pixels, lager window will remove noise more efficiently. The window may be in any shape like the box.An averaging filter is useful for removing grain noise from the image. Because each pixel is set to the average of its pixels, local differences resulting from the grain are reduced.

$$h(i,j) = \frac{1}{mn} \sum_{k \in m} \sum_{l \in n} f(k,l) \qquad (3.6)$$

IV. QUALITY METRICS

The following parameters will give us information about despeckle the noise. Based upon the image and parameters used, the results vary. These parameters are illustrated by M. Mrak [7] et.al, A.M.Eskicioglu [8] et.al and Avicibas [9] et.al.

Peak Signal to Noise Ratio (PSNR): It is an important measure the quality of the restored image when due to noise and blurry. PSNR is the ratio between the maximum signal capacity and the power of the damaged noise. This is the factor that governs whether the method provides a good noise reduction scheme or not. If the PSNR value as much as higher, image quality will be more. It plays a crucial role in all image processing areas.

$$PSNR = 10\log \frac{255*255}{\text{MSE}} \text{dB} \qquad (4.1)$$

Where, MSE is Mean Square Error [10].

Average Difference (AD): The average difference is the pixel difference between the filtered image and its degraded image. [14]

$$AD = \sum_{j=1}^{M} \sum_{K=1}^{N} \left[X(j,k) - \hat{X}(j,k) \right] \Big/ MN \qquad (4.2)$$

Structural Content (SC): It deals with spatial arrangements of pixels in an image.

$$\text{SC} = \sum_{j=1}^{M} \sum_{k=1}^{N} X(j,k)^2 \Big/ \sum_{j=1}^{M} \sum_{k=1}^{N} \hat{X}(j,k)^2 \qquad (4.3)$$

Image Fidelity (IF): It measures the affinity of an image from its ideal image.

$$\text{IF} = 1 - \sum_{j=1}^{M} \sum_{K=1}^{N} \left[X(j,k) - \hat{X}(j,k)^2 \right] \Big/ \sum_{j=1}^{M} \sum_{k=1}^{N} \left[X(j,k)^2 \right] \qquad (4.4)$$

Normalized Correlation Coefficient (NCC): It is the measure of similarity between two set of images.

$$NK = \sum_{j=1}^{M}\sum_{K=1}^{N}\left[X(j,k)\hat{X}(j,k)\right] \Big/ \sum_{j=1}^{M}\sum_{k=1}^{N}\left[X(j,k)^2\right] \qquad (4.5)$$

V. RESULTS AND DISCUSSION

In this work, Scanned images from Matlab software are taken for analysis. The experiment was done by MATLAB version R2013a.Here Speckle reduction filters are used Frost filter, Gaussian smooth filter and Averaging filter for all types of scanned images.

Table1: Performance analysis of image quality measures of Greens image

Speckle noise level 0.01				
Denoising Filter	PSNR	AD	SC	NCC
Frost	40.6236	2.4099	1.0821	0.96128
Gaussian smooth	29.086	0.13587	1.0805	0.9518
Averaging	27.2448	4.5782	1.19	0.90344
Speckle noise level 0.025				
Denoising Filter	PSNR	AD	SC	NCC
Frost	40.6806	2.3911	1.0817	0.96147
Gaussian smooth	28.3398	0.13667	1.0864	0.94718
Averaging	26.4944	4.8423	1.2068	0.89439

Table2: Performance analysis of image quality measures of Hestain image

Speckle noise level 0.01				
Denoising Filter	PSNR	AD	SC	NCC
Frost	33.4158	7.3844	1.087	0.95912
Gaussian smooth	26.9158	0.70102	1.0189	0.9869
Averaging	25.9783	3.5258	1.0498	0.97157
Speckle noise level 0.025				
Denoising Filter	PSNR	AD	SC	NCC
Frost	33.52	7.2566	1.0859	0.95961
Gaussian smooth	23.7906	0.69669	1.03	0.97762
Averaging	22.5262	4.4781	1.0702	0.95676

Table3: Performance analysis of image quality measures of Gantrycrane image

Speckle noise level 0.01				
Denoising Filter	PSNR	AD	SC	NCC

Frost	41.0941	2.9391	1.0849	0.96004
Gaussian smooth	30.3023	0.13624	1.0476	0.9675
Averaging	28.7498	2.6464	1.1244	0.9307
Speckle noise level 0.025				
Denoising Filter	PSNR	AD	SC	NCC
Frost	41.1534	2.893	1.0838	0.96055
Gaussian smooth	28.6866	0.1365	1.0596	0.95786
Averaging	27.0301	3.3283	1.1575	0.91144

Table4: Performance analysis of image quality measures of Peppers image

Speckle noise level 0.01				
Denoising Filter	PSNR	AD	SC	NCC
Frost	36.0057	4.9617	1.0889	0.95832
Gaussian smooth	30.8421	0.13764	1.0107	0.99185
Averaging	29.393	1.8172	1.0329	0.98007
Speckle noise level 0.025				
Denoising Filter	PSNR	AD	SC	NCC
Frost	46.1245	4.8732	1.088	0.95871
Gaussian smooth	27.3902	0.13874	1.0204	0.98358
Averaging	25.8044	2.4578	1.0489	0.96744

A plot against PSNR values and speckle noise levels using Frost filter, Gaussian smooth filter, Averaging filter for Greens image, Hestain image, Gantry crane image, Peppers image as shown in figure 4, figure 5, figure 6, figure7. From this figures PSNR values of frost filter gives good result for every images. Figure4 and figure6 gives more quality of image with high PSNR image using frost filter.

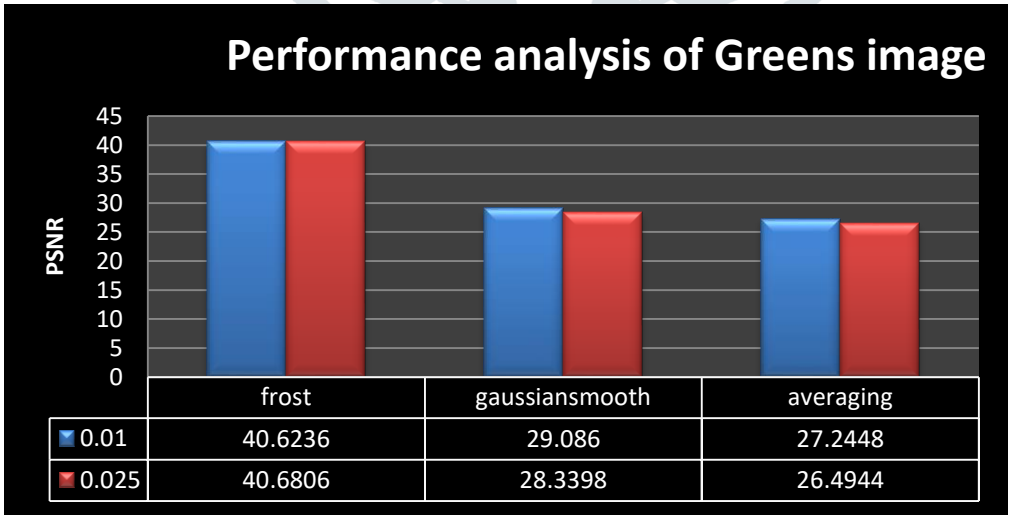


Figure4: Comparison between PSNR values and different speckle noise levels of Greens image

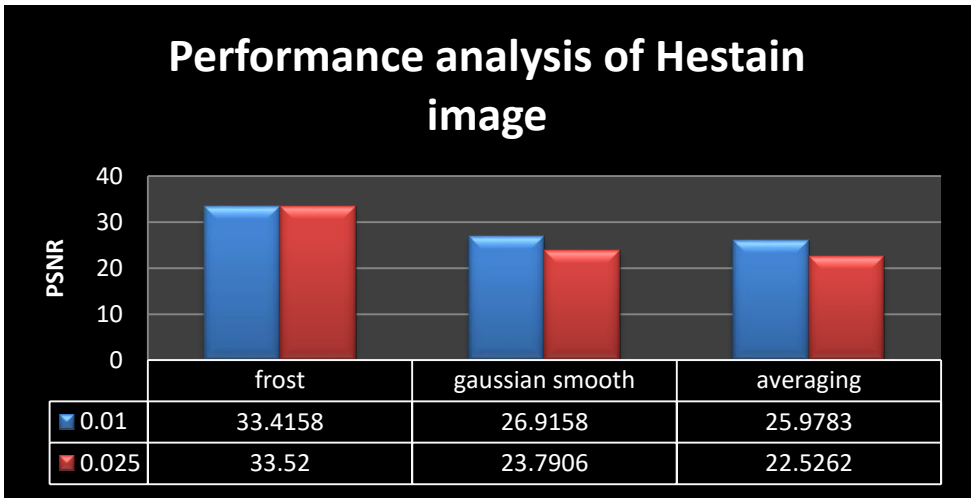


Figure5: Comparison between PSNR values and different speckle noise levels of Hestain image

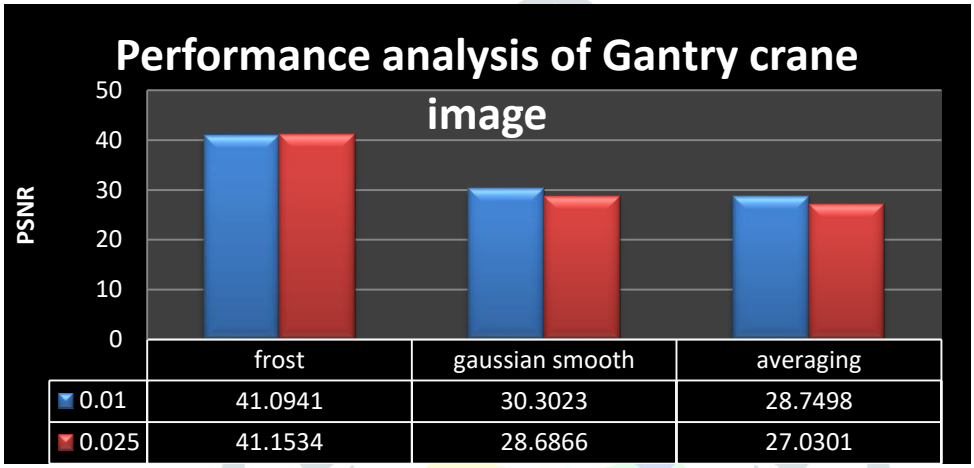


Figure6: Comparison between PSNR values and different speckle noise levels of Gantrycrane image

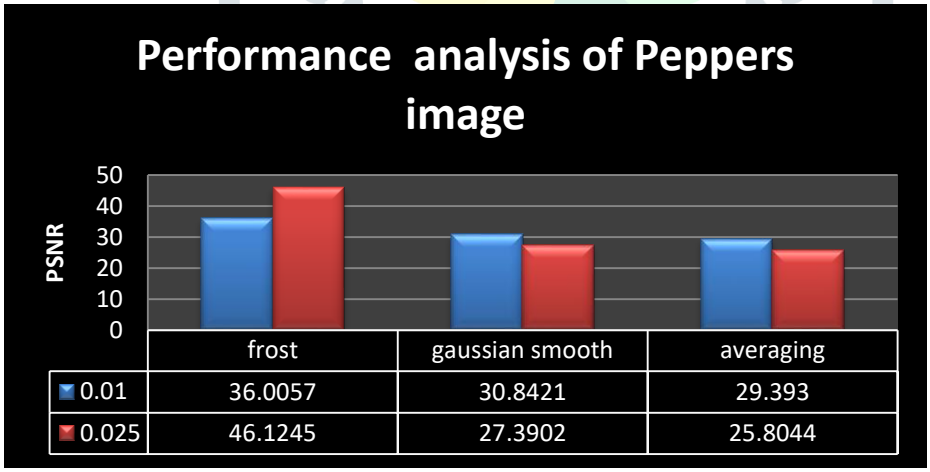


Figure7: Comparison between PSNR values and different speckle noise levels of Peppers image

CONCLUSION

In this work we have taken different scanned images from the matlab software to detect noise. The above scanned images are applied various filtering techniques like Frost filter, Gaussian smooth filter and averaging filter. The results are analyzed and evaluated by the quality metrics such as peak signal to noise ratio, average difference, image fidelity, normalized correlation coefficient, and structural content. This experimental analysis will improve the accuracy of greens image and gantry crane image. The results we have achieved are more useful and prove to be useful.

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