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Feature Variance Based Filter For Speckle Noise Removal

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Abstract: *Reducing noise from the various images like Real images, medical images and satellite images etc. is a challenging task in digital image processing. Noises are removed as pre processing which are needed for image enhancement, restoration, compression, registration, analysis as well as feature extraction and texture analysis. Several approaches are there for noise reduction. The proposed filtering technique in this paper removes speckle noise from the real images effectively. Quantitative analysis is done by various measures like Noise Variance, Mean Square Error, Noise Mean Value, Noise Standard Deviation, Equivalent Number of Looks (ENL) and PSNR and the results exhibit the performance of the proposed filter.*
Keywords: *ENL, frost filter, lee filter, PSNR, Speckle noise, speckle filters.*

I. Introduction

Digital Image Processing includes analysis, manipulation and storage of a two dimensional (2D) digital images represented as discrete values, either in spatial or frequency domain. The low–level image processing deals noise reduction, contrast enhancement and image sharpening using which the low quality image is made more suitable for further processing and the mid–level image processing deals with image segmentation, using which the regions of interest are subjectively secluded. In high–level image processing, the features, textures and other details of the image are identified subsequent analysis [1].

Normally an image may corrupted by noise by its acquisition and transmission. It is necessary to remove such noises as much as possible and retain the important signal features. Generally, the intensity or brightness of an image is to be uniform except where it changes to form an image. This changes produce variation in the intensity of the image even when no image detail is present. This variation is typically random and has no particular pattern. This random variation in image brightness is noise and it reduces image quality. This noise can be either dependent or independent to the original image. All the digital images contain some kind of visual noise [2]. The noisy images may speckled, gritty, snowy or patterned for visual. Salt & pepper noise, Gaussian noise, Poison noise, and Speckle noise are some of the popular examples of noise.

Salt and Pepper Noise is also called as impulse noise, spike noise, random noise or independent noise. Black and white dots appear in the image and looks like salt and pepper in an image. Sharp and sudden changes of image signal produce this noise. That is dust particles in the image acquisition source or over heated faulty components can cause this type of noise. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions [3]. 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.

Poisson noise is known as shot noise. It is an electronic noise that occurs when number of photons sensed by the sensor is not sufficient to provide detectable statistical information. This noise has root mean square value proportional to square root intensity of the image. Independent noise values affect different pixels in the image. In general the photon noise and other sensor based noise corrupt the signal at different proportions [4].

Gaussian Noise model is an additive noise and also follow Gaussian distribution. Every pixel in the noisy image is the sum of the true pixel value and a random, Gaussian distributed noise value [5]. The noise pixel intensity at each point is independent.

Speckle noise is common to all imaging systems which utilize a coherent mechanism to acquire images and is defined as multiplicative noise that alters the real intensity values of features in an image. In coherent systems, backscatter signals add to each other coherently and random interference of electromagnetic signals causes the speckle noise to occur in the image. Speckle degrades the quality of images and thereby reducing the ability of a human observer to discriminate the fine details [6]. The presence of the speckle noise affects image interpretation by human and the accuracy of computer-assisted techniques. Low image quality is an obstacle for effective feature extraction, analysis, recognition and quantitative measurements. Image variances or speckle is a granular noise that inherently exists in and degrades the quality of the images. Speckle noise filters are explained in section II. The proposed technique is given in section III. The results and discussions are detailed in section IV and the conclusion in section V.

II. Speckle Noise Filters

Filtering is one of the common methods which are used to reduce the noises and used as preface action before segmentation and classification. Though there are many speckle reduction techniques, there is no comprehensive method that takes all the constraints into consideration [7].

Speckle noise affects all coherent imaging systems including real, medical and SAR images. Within each resolution cell a number of elementary scatterers reflect the incident wave towards the sensor. The backscattered coherent waves with different phases undergo a constructive or a destructive interference in a random manner. The acquired image is thus corrupted by a random granular pattern, called speckle that delays the interpretation of the image content. A speckled image is commonly modeled $G(i,j)=f(i,j).\eta(i,j)$,Where the speckle $G(i,j)$ is the product of the original image $f(i,j)$ and the non-Gaussian noise $\eta(i,j)$.

Speckle filtering consists of moving a kernel over each pixel in the image and applying a mathematical calculation using the pixel values under the kernel and replacing the central pixel with the calculated value. The kernel is moved along the image one pixel at a time until the entire image has been covered. By applying the filter a smoothing effect is achieved and the visual appearance of the speckle is reduced [8].

Mean filter is an averaging linear filter [9]. The Mean Filter averages it into the data and does not remove the speckles. It is used for applications where resolution and details are not concerned. The median filter is a sliding-window spatial filter and removes pulse or spike noises. It replaces the center value in the window with the median of all the pixel values in the window. The computational cost of the median filter is its very high. Here the filter computes the average value of the corrupted image in a pre-decided area. Then the center pixel intensity value is replaced by that average value. This process is repeated for all pixel values in the image.

Median filter is a best order static, non- linear filter, whose response is based on the ranking of pixel values contained in the filter region. Median filter is quite popular for reducing certain types of noise. Here the center value of the pixel is replaced by the median of the pixel values under the filter region Median filter is good for salt and pepper noise. These filters are widely used as smoothers for image processing, as well as in signal processing [9]. While comparing the median filter is better than the mean filter by preserving the edges between two different features, but it does not preserve single pixel-wide features, which will be altered if speckle noise is present. The mean and median filters meet with only limited success when applied to SAR data. One reason for this is the multiplicative nature of speckle noise, which relates the amount of noise to the signal intensity. The other reason is that they are not adaptive filters in the sense that they do not account for the particular speckle properties of the image. The mean filter is one of the most widely used low-pass filters. It does an excellent job of smoothing areas, but creates problems in that it smears the edges and fine features together with the speckle noise, thus failing to preserve image structure[10].

The Frost filter is an adaptive and exponentially-weighted averaging filter based on the coefficient of variation which is the ratio of the local standard deviation to the local mean of the degraded image. The Frost filter replaces the pixel of interest with a weighted sum of the values within the next moving kernel. The weighting factors decrease with distance from the pixel of interest. The weighting factors increase for the central pixels as variance within the kernel increases. This filter assumes multiplicative noise and stationary noise statistics. The un-speckled pixel value is estimated using a sub-window of the processing window. The size of the sub-window varies as a function of target local heterogeneity measured with coefficient of variation. The larger the coefficient of variation narrows the processing sub window[11].

Lee filter is based on the assumption that the mean and variance of the pixel of interest are equal to the local mean and variance of all pixels within the user-selected moving window. The Lee filter removes the noise by minimizing either the mean square error or the weighted least square estimation whereas the Frost filter replaces the pixels of interest with a weighted sum of the values within the moving window. The weighting factors decrease with distance from the pixel of interest and increase for the central pixels as variance within the window increases. This filter assumes multiplicative noise and stationary noise statistics [12].

The Lee-sigma filter is an alternative to the Lee and is conceptually simple but effective. It first computes the sigma or standard deviation of the image and then replaces each central pixel in a moving window with the average of only those neighboring pixels that have an intensity value within a fixed sigma range of the central pixel. The fixed sigma computed for the image blurs some of the low-contrast edges and linear features. So, the local standard deviation for each moving window is used as the sigma parameter[13].

III. Proposed Work

The proposed technique is intended to denoise speckle image using variance and dissimilarity. The algorithmic description of the proposed technique is given herein under:

Algorithm:

1. Read the input image in_image
2. Find the texture features feat_vari and feat_diss
3. Find sq_var and sq_dissi square root of feat_vari and feat_dissi respectively
4. For all pixels in image

/* Remove the dissimilarity from the noisy image

5. Calculate mod_img by subtracting sq_diss
6. Repeat step 4
7. For all pixels in image
8. If mod_img value!=0
9. Find the sum of neighboring pixels
10. Divide the sum with sq_var
11. Repeat step 7
12. Display the resultant out_image
13. Stop.

IV. Results Analysis And Discussion

There are several methods to assess the filtered image quantitatively according to different aspects such as noise reduction, edge preservation, and feature preservation. The results of these different measurements can be contradictory. Hence, different assessment methods should be used to find the optimum tradeoff among the different aspects of image quality assessment. In this work, the assessment parameters that are used to evaluate the performance of speckle reduction are Noise Variance, Mean Square Error, Noise Mean Value, Noise Standard Deviation, Equivalent Number of Looks (ENL), PSNR and SSI.

Equivalent Numbers of Looks (ENL)

Another good approach of estimating the speckle noise level in an image is to measure the ENL over a uniform image region. A larger value of ENL usually corresponds to a better quantitative performance. The value of ENL also depends on the size of the tested region, theoretically a larger region will produces a higher ENL value than over a smaller region but it also tradeoff the accuracy of the readings. The formula for the ENL calculation is

$$ENL = \left(\frac{mean}{std}\right)^2$$

Noise Mean Value (NMV), Noise Variance (NV), and Noise Standard Deviation (NSD)

NV determines the contents of the speckle in the image. NV is used to determine the amount of smoothing needed for each case for all filters. A lower variance gives a cleaner image as more speckle is reduced, although, it not necessarily depends on the intensity. The formulas for the NMV, NV and NSD calculation are

$$NMV = \frac{\sum_{r,c}^{I_f}(r,c)}{R * C}$$

$$NV = \frac{\sum_{r,c}[(I]_f\ (r,c) - NMV)^2}{R * C}$$

$NSD = \sqrt{NV}$ where R-by-C pixels is the size of the filtered image If .

Mean Square Error (MSE)

MSE is the measure of the extent to which the output image differs from the input image. This helps indirectly to assess the feature preservation.

$$MSE = \frac{1}{K} * \left(\sum [S_i - S_O)]\right)$$

where Si is the noisy input image, So is the filtered output image and K is the size of the image. Accurate filtering of images with high noise content could also lead to large values of MSE.

Peak Signal to Noise ratio (PSNR)

PSNR gives the strength of the pure signal or image, as compared to the noise present which is removed by the filter. Higher PSNR emulates better performance.

$$SNR = 10\ log_{10}\left(\sum \frac{S_o}{[(S]_{i-}S_o)^2}\right)$$

The proposed technique is implemented using MATLAB 6.5 and it is tested with various images. The output of the proposed algorithm is shown in Fig1 and the evaluation methods with corresponding values are shown in TABLE. Although all these speckle filters perform well on images it has some constraints regarding resolution degradation and are also less familiar due to their algorithmic complexity. These filters operate by smoothing over a fixed window, whose size is determined by two factors. In Homogeneous area large window size is needed to improve speckle reduction. But large window size reduces the resolution of the algorithm. The following Fig1 shows the noisy input image and output of proposed filter followed by Frost filter, Lee filter and Wiener filter. Among all the proposed method performs well in terms of ENL, NV, NMV, NSD, MSE, PSNR, and visual quality. TABLE exhibits the performance of the proposed filter compared with other filters.

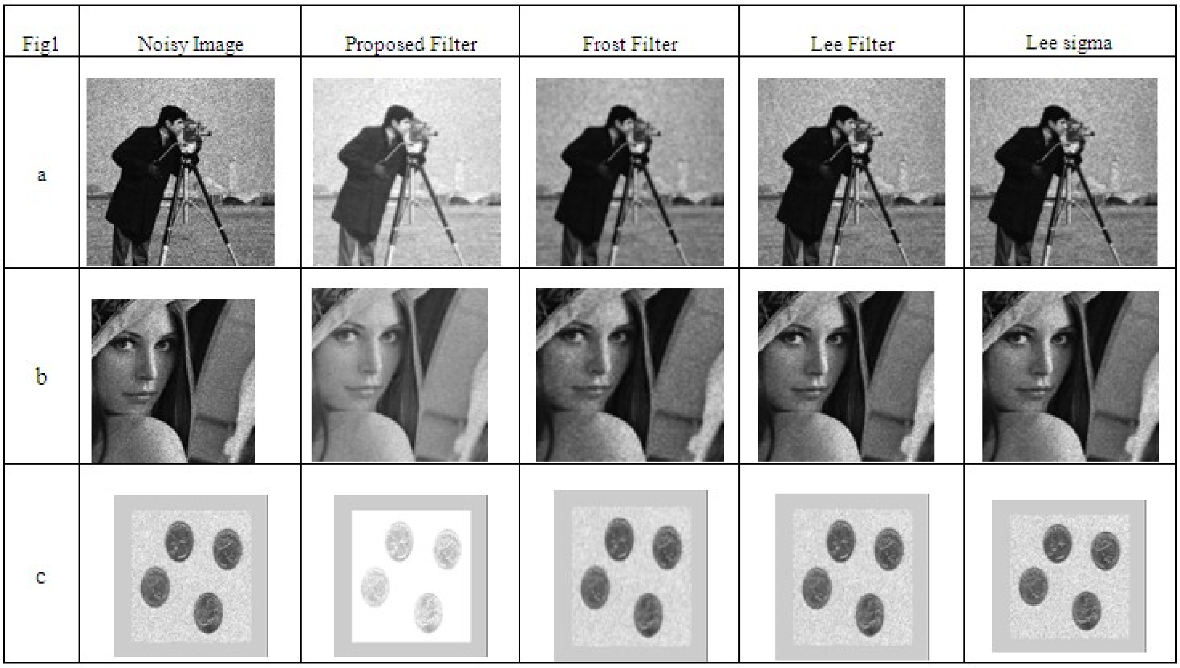

Fig 1

Performance Comparision Table

Evaluation Methods	cameraman image					Lena image					Coin image				
	Noisy Image	Proposed filter	Frost filter	Lee filter	Lee-sigma	Noisy Image	Proposed filter	Frost filter	Lee filter	Lee sigma	Noisy Image	Proposed filter	Frost filter	Lee filter	Lee sigma
ENL	2.96	8.46	4.04	3.86	3.86	2.62	9.17	3.36	3.16	3.16	10.005	47.647	16.218	15.161	16.11
MSE	18770	0.551	17126	17740	17740	11900	0.287	17000	11400	11400	39901	1. 1.342	38505	38667	39867
NV	4730	0.057	3466	3637	3637	3300	0.028	2530	2730	2730	3625.8	0.027341	2236.4	2392.7	2432.7
NSD	68.79	0.238	58.84	60.31	60.31	57.47	0.168	50.37	52.33	52.33	156.63	0.16535	47.29	48.915	49.02
NMV	118	0.695	117.34	118.71	118.71	93.13	0.508	92.4	93.13	93.13	190.46	1.1414	190.44	190.46	191.0
PSNR	162.1	182.46	163.04	162.83	162.83	162.5	183.21	163.22	163.05	163.05	157.57	178.41	156.6	156.62	157

Equivalent No of Looks (ENL), Mean Square Error(MSE), Noise Variance(NV), Noise Standard Deviation(NSD), Noise Mean Value(NMV), Peak to Signal Noise Ratio(PSNR)

V. Conclusion

This proposed work outperforms the standard speckle filters frost and lee methods. However, by visual inspection it is evident that the denoised image, while removing a substantial amount of noise. Experimental results show that the proposed method yields significantly improved visual quality as well as better Equivalent No of Looks (ENL), Mean Square Error(MSE), Noise Variance(NV), Noise Standard Deviation(NSD), Noise Mean Value(NMV), Peak to Signal Noise Ratio(PSNR) compared to the other techniques in the denoising literature.

References

[1]. P. Shanmugavadivu, A. Shanthasheela, Performance Analysis of Localized Texture-Based Decomposition Using Gabor Filter, National Conference on Information Technology and its Applications, A.V.C College of Engineering, Mayiladuthurai, Oct. 09, 2009

[2]. Gonzalez, R. C. and Woods, E. “Digital Image Processing”, 3nd ed.,Pearson Education (South Asia) 2009.

[3]. Pei-Yin Chen, Chih-Yuan Lien: An Efficient Edge-Preserving Algorithm for Removal of Salt-and-Pepper Noise. IEEE Signal Process. Lett. (SPL) 15:833-836 (2008)

[4]. Florian Luisier, Thierry Blu, Michael Unser: Image Denoising in Mixed Poisson-Gaussian Noise. IEEE Transactions on Image Processing (TIP) 20(3):696-708 (2011)

[5]. Russo F. A method for estimation and filtering of Gaussian noise in images. IEEE Transactions on Instrumentation and Measurement. 2003;52(4):1148–1154

[6]. Koo J, Oark SB. Speckle reduction with edge preservation in medical ultrasonic images using a homogenous region growing mean filter (HRGMF). Ultrasonic Imaging. 1990;13:629–639

[7]. Lu YH, Tan SY, Yeo TS, Ng WE, Lim I, Zhang CB. Adaptive filtering algorithms for SAR speckle reduction. IGARSS. 1996;1:67–69

[8]. [8] Ridha Touzi: A review of speckle filtering in the context of estimation theory. IEEE T. Geoscience and Remote Sensing (TGRS) 40(11):2392-2404 , 2002

[9]. Pierrick Coupé, Pierre Hellier, Charles Kervrann, Christian Barillot: Bayesian non local means-based speckle filtering. ISBI 2008:1291-1294

[10]. Chedsada Chinrungrueng: Combining Savitzky-Golay filters and median filters for reducing speckle noise in SAR images. SMC,690-696, 2003.

[11]. Victor S. Frost, Josephine Abbott Stiles, K. Sam Shanmugan, Julian C. Holtzman: A Model for Radar Images and Its Application to Adaptive Digital Filtering of Multiplicative Noise. IEEE Trans. Pattern Anal. Mach. Intell. (PAMI) 1982, 4(2):157-166 ,

[12]. Lee JS. Digital image enhancement and noise filtering by use of local statistics. IEEE Transactions on Pattern Analysis and Machine Intelligence. 1980;PAMI-2:165–168

[13]. Lee, J. S., Improved sigma filter for speckle filtering of SAR imagery," IEEE Transcations on Geoscience and Remote Sensing, Vol. 47, No. 1, 202-213, Jan. 2009.