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Novel Approach to Reduce Speckle Noise from Images using Adaptive Thresholding

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*Abstract: **Different type of noises get added while transforming and acquiring images. It is important to restore key features that are affected by noise. Researches show that Wiener filter is the most advanced and robust method to reduce both additive and multiplicative noise from different type of images. In this paper we are working on speckle noise reduction methods. We implemented Median filter, Wiener filter and a novel approach is proposed by using adaptive thresholding for reduction of speckle noise. We also compared all the three methods in terms of PSNR and MSE.***

Keywords: Threshold, PSF, Blur kernel, DFT, MSE, PSNR

I. INTRODUCTION

Different devices are used to capture information in the form of text, audio, video or an image. Researchers always want to explore the limits of their equipment, and also desire to recover the hidden information and visualize it to facilitate interpretation. Taking into account the processes that take place in the equipment that gather the information, we can model which information is "lost" and which information is still present in a "hidden" form. Then, we can design solutions to recover this hidden information.

The field of picture preparing concentrates on mechanizing the procedure of social affair and transforming visual data. While transforming or acquiring the images, the quality of the image gets degraded by noise. The performances of imaging sensors are affected by variety of factors such as environmental conditions during image acquisition and by quality of the sensing elements themselves [11]. Image restoration attempts to reconstruct or recover an image that has been degraded by noise or the photometric reasons. It images an ideal mathematical point not as a point but as a smeared-out spot because of the wave nature of light. This image of an ideal point is the so-called Point Spread Function (PSF). This causes image blurring, even with a well aligned system: all optical systems have a finite resolution, even when optimally tuned; of course, with misalignment of the optical components, the situation degrades even further. So the optical system produces a blurred image of the object, which is then recorded by some detector system, like a CCD. The final recorded image has in fact been blurred and corrupted by noise, which results in the loss of actual information. However, it is not because some feature is invisible that this feature is lost.

It can be due to as :

- often details are hidden in the noise or masked by other features;
- artifacts may confuse the viewer;
- information may be present in implicit form, i.e., it can only be retrieved when one imposes prior knowledge.

Type of noise present in an image can be multiplicative and additive. Additive noise is systematic in nature and can be easily modeled and hence removed or reduced easily. Whereas multiplicative noise is image dependent, complex to model and hence difficult to reduce. Additive noise is the noise which adds up in the original image. Multiplicative noise is the noise which multiplies with the original image. Different types of noises are Gaussian noise, Salt & Pepper noise, Speckle noise and Poisson noise [11].

II. SPECKLE NOISE

Speckle noise happens when a sound wave beat haphazardly interferes with little particles or protests on a scale tantamount to sound wavelength. Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. [11]

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 in SAR is generally more serious, causing difficulties for image interpretation. It is caused by coherent processing of backscattered signals from multiple distributed targets. [11]

Like the light from a laser, the waves emitted by active sensors travel in phase and interact minimally on their way to the target area. After interaction with the target area, these waves are no longer in phase because of the different distances they travel from targets, or single versus multiple bounce scattering. Once out of phase, radar waves can interact to produce light and dark pixels known as speckle noise. Speckle noise in radar data is assumed to have multiplicative error model and must be reduced before the data can be utilized otherwise the noise is incorporated into and degrades the image quality.

A. Features of Speckle Noise:

1) Speckle noise in SAR is a multiplicative noise, i.e. it is in direct proportion to the local grey level in any area.
2) The signal and the noise are statistically independent of each other.
3) The sample mean and variance of a single pixel are equal to the mean and variance of the local area that is centred on that pixel. [1], [2], [6].

III. NEED FOR FILTERING

Speckle noise degrades the quality of Ultrasound (US), Synthetic aperture radar (SAR), scanned and photographic images and thereby in Ultrasound and SAR images reducing the ability of a human observer to discriminate the fine details of diagnostic examination. Hence images with speckle noise will results in reducing the contrast of image and difficult to perform image processing operations like edge detection. Filtering is a class of signal processing, the characterizing features of channels being the complete or fractional suppression of some part of the signal. Most often, this means removing some frequencies and not others in order to suppress interfering signals and reduce background noise.

IV. FILTRATION techniques

Several different methods are used to eliminate speckle noise, based upon different mathematical models of the phenomenon. One method, for example, employs multiple-look processing, averaging out the speckle noise by taking several "looks" at a target in a single radar sweep. The average is the incoherent average of the looks.

The spatial filters are categorized into two different groups, i.e. non-adaptive and adaptive. Non-adaptive channels apply the same weightings consistently over the whole picture take the parameters of the entire picture signal into attention and forget the neighbourhood properties of the territory backscatter or the nature of the sensor. These kinds of filters are not appropriate for non-stationary scene signal.

On the other hand, adaptive filters accommodate changes in local properties of the terrain backscatter as well as the nature of the sensor. Adaptive filters adapt their weightings across the image to the speckle level, the speckle noise is considered as being stationary but the changes in the mean backscatters due to changes in the type of target are taken into consideration. Adaptive filters reduce speckles while preserving the edges (sharp contrast variation) and detail in high texture areas. Adaptive filters changes the complexity stretch for every pixel relying on the Digital Number (DN) values in the surrounding moving kernel. These filters adjust the picture focused around facts extracted from the nearby environment of every pixel. Clearly, a filter that adjusts the stretch to the area of interest (the area inside the moving portion) would create a finer upgrade.[9]

A. Median Filter:

The best-known order-statistics filter is the median filter, which, as its name implies, replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel. The original value of the pixel is included in the computation of the median. Median filters are quite popular because, for certain types of random noise, they provide excellent noise-reduction capabilities, with considerably less blurring than linear smoothing filters of similar size. Median filters are particularly effective in the presence of both bipolar and unipolar impulse noise. A major advantage of the median filter is that the median filter can eliminate the effect of input noise values with extremely large magnitudes. The output y of the median filter at the moment t is calculated as the median of the input values corresponding to the moments adjacent to t.

$$y(t) = median\left(x\left(t-\frac{T}{2}\right), x(t-T_1+1), \dots, x(t), \dots, x\left(t+\frac{T}{2}\right)\right).$$

where t is the size of the window of the median filter. [6]

B. Wiener filter:

This filter was created by Norbert Wiener. He was a pioneer in the study of stochastic and noise processes, contributing work relevant to electronic engineering, electronic communication, and control systems. Wiener also founded cybernetics, a field that formalizes the notion of feedback and has implications for engineering, systems control, computer science, biology, philosophy, and the organization of society

The Wiener filter has a long history that goes back to the Wiener-Hopf equations derived by Norbert Wiener and Eberhard Hopf in 1930. The Wiener filter is in fact a solution of these equations. Wiener filter proposed in the year of 1942. In essence, the Wiener filter behaves similar to the truncated inverse filter, except that an optimal trade-off is made in the area where the noise power becomes of the same order of magnitude as the signal power. In fact, the truncated inverse filter amplifies the amplitude of the spectral components of the signal for whose energy dominates that of the noise; spectral components 40 Classical restoration techniques with energy smaller than the noise energy are set to zero. On the other hand, the Wiener filter also amplifies the amplitude of the spectral components of the signal whose energy dominates the noise energy, but performs an optimal least-square shrinkage of the spectral components where the noise starts to dominate the signal.[23]

This general idea can be applied whenever you have a basis in function space that concentrates "mostly signal" in some components relative to "mostly noise" in others. Components with too much noise are set to be zero. Wiener filter gives the optimal way of tapering off the noisy components, so as to give the best reconstruction of the original signal. Different bases are not equivalent, because, in particular problems, signal and noise distribute differently in them.

Wiener filter is also known as least mean square filter. It is adaptively applied on the image according to the local image variance. It minimizes the overall mean square error in the process of inverse filtering and noise smoothing. It is the linear estimation of the original image. If the variance is small, wiener performs smoothly; if the variance is large then the wiener performs less smoothly. It works best both in additive and multiplicative noise.

Wiener Filter in Fourier Domain:

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

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 **Pn /Ps** can be interpreted as the reciprocal of the signal to noise ratio. [6]

V. PARAMETERS FOR COMPARISON

A. Peak Signal to Noise Ratio (PSNR):

It is a value that is frequently used to evaluate the performance of restoration. It is defined as the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The operator with higher PSNR is considered as best for edge detection. [6].

$$PSNR = 10\log_{10}(MAX_i^{\,2} / MSE)$$

B. Mean square error (MSE) :

MSE of an estimator is to quantify the difference between an estimator and the true value of the quantity being estimated. [6]. It is the mean square error between the pixel intensities of the two images (ideal and restored).

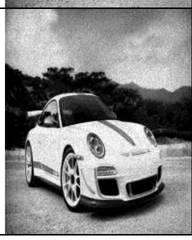
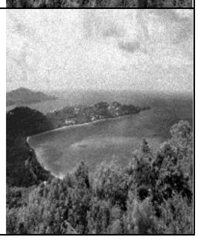
$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

VI. PROPOSED METHOD

1. Take two gray scale images one that is free from noise and the other one that contains speckle noise.
2. Create a blur kernel to apply blur effect to the image.
3. Calculate Discrete Fourier Transform of the image with noise.
4. Calculate Discrete Fourier Transform of blur kernel.
5. Multiply DFT of blurred image with complex conjugate of blur kernel.
6. Calculate Inverse Discrete Fourier Transform of the obtained image in step 5.
7. Apply adaptive threshold while plotting final pixel values of restored image.
8. Calculate PSNR and MSE of restored image by comparing it with the original image that is free from noise.

VII. EXPERIMENTAL RESULTS AND COMPARISON

Table 1 shows the experimental results of Median, Wiener and Proposed method.

	Image (a)	Image (b)	Image (c)	Image (d)	Image (e)
Original Image					
Image with Noise					

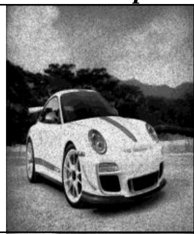
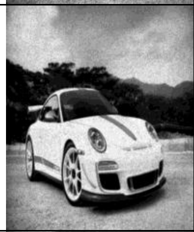
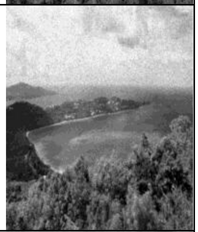
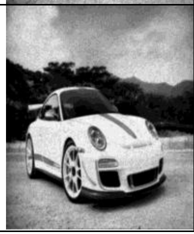
Median Filter					
Wiener Filter					
Proposed Method					

Table 2 shows the comparison of Median, Wiener and Proposed method on the basis of PSNR and MSE

Image (a)		
FILTER	**PSNR**	**MSE**
MEDIAN	18.4005	939.7803
WIENER	18.7355	870.0215
PROPOSED	18.8291	851.4690

Image (b)		
FILTER	**PSNR**	**MSE**
MEDIAN	22.6345	354.5087
WIENER	24.1685	249.0134
PROPOSED	24.3236	240.2811

Image (c)		
FILTER	**PSNR**	**MSE**
MEDIAN	19.5865	715.2037
WIENER	27.0171	129.2318
PROPOSED	27.3895	118.6099

Image (d)		
FILTER	**PSNR**	**MSE**
MEDIAN	18.0915	1009.0687
WIENER	23.3396	301.3799
PROPOSED	23.5375	287.9580

Image (e)		
FILTER	**PSNR**	**MSE**
MEDIAN	17.7417	1093.7193
WIENER	23.0739	320.3943
PROPOSED	23.3373	301.5417

VIII. CONCLUSION

In this paper a novel approach is proposed using adaptive thresholding for reduction of speckle noise from gray scale images. We have also compared our proposed approach with traditional filters like Median and Wiener filter. In previous researches Wiener is considered as best to reduce speckle noise from an image. It is used for reduction of additive as well as multiplicative noise. We have used PSNR and MSE as evaluative parameters for comparing the results. After comparing them with our proposed method, It has been observed that PSNR of proposed method is higher than other two filters and less in case of MSE. So, It is concluded that our novel approach is a better technique for reduction of speckle noise from images.

REFERENCES

[1] Inderjeet Singh and Er. Lal Chand, "Speckle Noise Reduction based on Discrete Wavelet Transform", International Journal of Computer Trends and Technology (IJCTT) – volume 4 Issue 7–July 2013, ISSN: 2231-2803, Page 2222.

[2] Bhausaheb Shinde, Dnyandeo Mhaske, Machindra Patare, A.R. Dani, " Apply Different Filtering Techniques To Remove The Speckle Noise Using Medical Images", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 ,Vol. 2, Issue 1,Jan-Feb 2012, pp.1071-1079.

[3] Arpit Singhal, Mandeep Singh, "Speckle Noise Removal and Edge Detection Using Mathematical Morphology", International Journal of Soft Computing and Engineering (IJSCE), ISSN: 2231-2307, Volume-1, Issue-5, November 2011.

[4] K.Bala Prakash, R.Venu Babu, B.VenuGopal," Image Independent Filter for Removsl of Speckle Noise", International Journal of Computer Science Issue, Vol. 8, Issue 5, No. 3, September 2011, ISSN (Online): 1694-0814.

[5] Haryali Dhillon1, a, Gagan Deep Jindal2, b, Akshay Girdhar, "A Novel Threshold Technique for Eliminating Speckle Noise In Ultrasound Images", 2011 International Conference on Modeling, Simulation and Control, IPCSIT vol.10 (2011) © (2011) IACSIT Press, Singapore.

[6] Pawan Patidar, Manoj gupta, Sumit srivastava, ashok kumar nagawat, , "Image De-noising by Various Filters for Different Noise", International Journal of Computer Applications (0975 – 8887) Volume 9– No.4, November 2010.

[7] S.Sudha, G.R.Suresh and R.Sukanesh, "Speckle Noise Reduction in Ultrasound Images by Wavelet Thresholding based on Weighted Variance", International Journal of Computer Theory and Engineering, Vol. 1, No. 1, April 2009,1793-8201.

[8] Sanket Manohar Gokhale, Parvez E. Ansari, Snehal R Kochre, " A Novel Approach for Minimization of Speckle Noise in Ultrasound Imaging Using Redundant Discrete Wavelet Transform" , IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676, p-ISSN: 2320-3331 PP 57-63, 2014.

[9] M. Mansourpour, M.A. Rajabi, J.A.R. Blais, "Effects and Performance of speckle noise reduction filters on active RADAR and SAR images.

[10] Josaphat Tetuko Sri Sumantyo and Jalal Amini," A model for removal of speckle noise in SAR images", Canadian Journal of Remote Sensing, Vol. 34, No. 6, pp. 503-515, 2008.

[11] Simrat et al.," Empirical Study of Various Speckle Noise Removal Methods", International Journal of Emerging Technologies in Computational and Applied Sciences, 8(6), March-May, 2014, pp. 513-516 .

[12] Fang Qiu, Judith Berglund, John R. Jensen, "Speckle Noise Reduction in SAR Imagery Using a Local Adaptive Median Filter", GIScience and Remote Sensing, 2004, 41, No. 3, pp. 244-266.

[13] S. Grace Chang, Bin Yu and Martin Vetterli," Adaptive Wavelet Thresholding For Image Denoising and Compression", IEEE Transactions On Image Processing, Vol. 9, No. 9, September 2000.

[14] Shi-qi-Huang, Dai-zhi Liu, Gui-qing Gao, Xi-jian Guao, "A novel method for speckle noise reduction and ship target detection in SAR images", Journal Pattern Recognition, Vol.No. 42, Issue- 7, July 2009.

[15] S Suryanarayana, Dr. B L Deekshatulu, Dr. K Lal Kishore , Y Rakeshkumar, "Automatic Detection Of Noise Type And Class Using Multiple Image Metrics ", International Journal Of Electronics And Communication Engineering & Technology (IJECET), ISSN 0976 – 6464(Print), ISSN 0976 – 6472(Online) Volume 3, Issue 2, July-September (2012).

[16] J.W.Goodman," Some fundamental properties of speckle", J.Opt. Soc. Amer, Vol. 66, No. 11, pp 1145-1149, 1976.

[17] F. Jin, P. Fieguth, L. Winger and E. Jernigan, "Adaptive Wiener Filtering Of Noisy Images And Image Sequences", IEEE 2003.

[18] Russell Hardie , A Fast Image Super-Resolution Algorithm Using an Adaptive Wiener Filter", IEEE Transactions on Image Processing,, Vol. 16, No. 12, December 2007.

[19] Hiroko Furuya, Shintaro Eda, Testuya Shimamura , "Image Restoration via Wiener Filtering in the Frequency Domain" , WSEAS Transactions on signal processing, ISSN: 1790-5052 , Issue 2, Volume 5, February 2009.

[20] William K. Pratt, "Generalized Wiener Filtering Computation Techniques", IEEE Transactions on Computers, Vol. C-21, No. 7, July 1972.

[21] Yih Jeng, Yi-Wei Li , Chih-Sung Chen, Hsin-Yi Chien, "Adaptive filtering of random noise in near-surface seismic and ground-penetrating radar data", Journal of Applied Geophysics 68 (2009) 36–46.

[22] Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Third edition, Pearson Prentice Hall.

[23] http://en.wikipedia.org/wiki/Wiener_filter.

