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Removing Speckle Noise using Filters from Digital Image and OCT Image: A Review

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Abstract—**During this modern age, visual information transmitted in the form of digital images is becoming a major method of communication, but the image obtained after transmission is often affected with noise. Similarly, Optical Coherence Tomography (OCT) technology introduces speckle, an insidious form of multiplicative Noise in OCT images. Therefore, Noise Suppression from both types of images is one of the most important concerns in image processing.**

In this paper a comparison is shown between an existing speckle denoising filters which were applied on digital image and on OCT image in order to increase their quality by removing noise from them. This comparison is done on the basis of image metrics like peak signal to noise ratio (PSNR) and root mean square error (RMSE).

Index Terms- **Optical Coherence Tomography, Speckle Noise, Denoising Filters.**

I. INTRODUCTION

Digital images play an important role both in daily life applications as well as in medical diagnosis. The available technologies in medical field are magnetic resonance imaging (MRI) and computer tomography (CT) which provides non-invasive images of human body. However these techniques, provides low resolution image because of their physical limitations.

In order to overcome this limitation an Optical Coherence Tomography [6] technology has being developed for imaging the internal structure of biological tissue in vivo with micron resolution. It is based on the coherence properties of light. This technology also has one limitation i.e. the presence of speckle noise which degrades the quality of OCT images [7]. All other technologies that are based on coherence properties of light are also affected by speckle noise.

It is found that Speckle noise is common in most types of images like Digital, OCT, SAR, Ultrasound etc. So, denoising this Speckle noise using appropriate filter is of great importance. Whereas, it is found that Speckle noise is well modeled by a multiplicative noise i.e. a signal dependent form of noise having a granular pattern. In this model, noise signal gets multiplied to the original signal. The Multiplicative Noise Model [8] follows the following rule:

$$W(x, y) = S(x, y) \times N(x, y) \qquad \text{---- (1)}$$

In the above equation W, S and N is noisy data, original signal and speckle noise respectively.

The other type of model is Additive Noise Model [8], in which the noise signal is added to the original signal. The rule is as follows:

$$W(x, y) = S(x, y) + N(x, y) \qquad \text{---- (2)}$$

Speckle degrades the quality of both digital and OCT images and thereby reducing the ability of human observer to discriminate the fine details in an image. So, in order to prevent the fine details in an image the processing is required on an image. In this paper, we will see some existing standard denoising filters used on both digital and OCT images to reduce the effect of speckle noise. In the further discussion we will see each of these filters in detail and compare each of them with others on the basis of image metrics i.e. PSNR and RMSE.

II. TYPES OF FILTERS

Kuan Filter:

The filter [1], the multiplicative noise model is first converted into a signal-dependent additive noise model. The Kuan Adaptive Noise Smoothing filter uses a minimum mean square error calculation to estimate the value of the true signal for the centre cell in the filter window from local statistics.

Frost Filter:

The frost filter [2] is an adaptive radar filter that incorporates the local image statistics in the filtering process, assuming a negative exponential distribution for the speckle noise. The filter smoothes more in homogeneous areas, but provides a signal estimate closer to the observed value of the centre cell in heterogeneous areas.

Lee Filter:

The Lee Filter [3] is basically used for speckle noise reduction. It is an adaptive filter that changes its characteristics according to the local statistics in the neighborhood of the current pixel. More smoothing occurs in a more uniform areas, while maintaining edges and other fine detail.

Wiener Filter:

The Wiener filter [4][5] purpose is to reduce the amount of noise present in a signal by comparison with an estimation of

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the desired noiseless signal. This filtering method is based on a statistical approach and requires the information about the spectra of noise and original signal. It works well only if the underlying signal is smooth.

III. Estimation of Statistical Parameters

Mean Square Error is given by:

$$MSE = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{\left(f(i,j) - F(i,j)\right)^2}{M * N}$$

$$RMSE = \sqrt{MSE}$$

Where f is the original image F is filtered image and M*N is the size of image. RMSE is an estimator to quantify the amount by which a noisy image differs from noiseless image.
PSNR is the ratio between possible power of a signal and a power of corrupting noise. It can be easily defined in decibels using RMSE as follows

$$PSNR = 20\log_{10}\left(\frac{255}{RMSE}\right)$$

Higher PSNR value provides higher image quality.

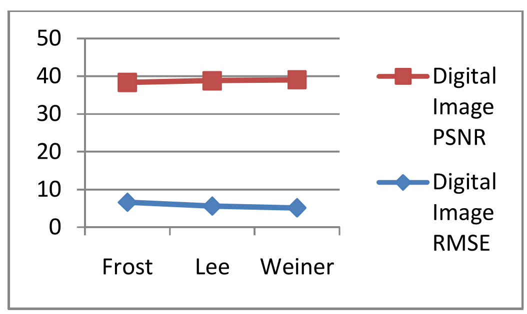
IV. Literature Survey

As the Lee and Kuan filters [1] have the same formation; both of these filters form an output image by computing a linear combination of the centre pixel intensity in a filter window with the average intensity of the window. So, here we will perform comparison between Frost, Lee and Wiener filters only.
The Frost filter [2] was developed by V. S. Frost. The response of this filter varies locally with the coefficient of variation. In case of low coefficient of variation, the filter is more average-like, and in cases of high coefficient of variation, the filter attempts to preserve sharp features by not averaging.
The Lee filter [3], developed by Jong-Sen Lee based on a linear speckle noise model and the minimum mean square error (MMSE) design approach; the filter produces the enhanced data. But the major drawback of this filter is that it leaves noise in the vicinity of edges and lines. However, it is still desirable to reduce noise in the edge area without sacrificing the edge sharpness.
There are two methods used in wiener filtering.
(i) Fourier-transform method (frequency-domain):
This method is used only for complete restoration and normally it requires a priori knowledge of power spectra of noise and the original image.
(ii) Mean-squared method (spatial-domain):
This method is used for denoising and no prior knowledge is required.
Hence, it is easier to use Mean-squared method for removing speckle noise from any digital or OCT image.
A. Stella and Dr. Bhushan Trivedi in June 2013 observed the following results after implementing this filters on Digital and OCT image. The calculated values of RMSE and PSNR are as follows:.

	Digital Image		OCT Image	
	RMSE	PSNR	RMSE	PSNR
Frost	6.5937	31..75	4.3619	35.34
Lee	5.5732	33.21	3.3685	37.58
Wiener	5.1358	33.92	2.3151	40.84

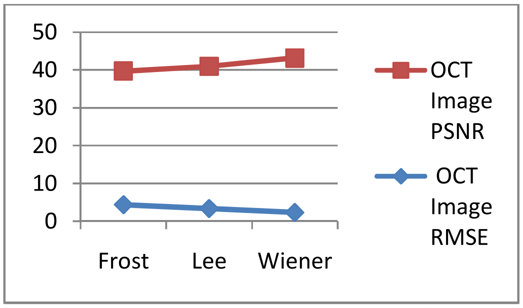
Sample values of RMSE and PSNR for Digital & OCT Image

They perform the comparison between the denoised digital and OCT image on the basis of statistical parameters, RMSE and PSNR. They observed that the calculated values of RMSE for OCT image are low as compared to the digital image. The filter with lower RMSE but higher PSNR is considered as a better one. The graph below shows the representation of denoised digital image using above available data.



Graphical Representation of RMSE and PSNR values for Digital image

The following is the graphical representation of denoised OCT image using above table values.



Graphical Representation of RMSE and PSNR values for OCT Image

In this review thus it is found that Weiner filter is observed as one of the most suitable filter which satisfies the condition, but still this filter is not able to completely remove speckle noise from an image. It is up to the mark above which it is not possible to remove noise from both OCT and Digital images using this Wiener filter.

CONCLUSION

In this paper we have seen some existing denoising filters for reducing speckle noise like Lee, Frost, Kuan and Wiener filters. The main objective of the filters is to properly satisfy the statistical factors mainly RMSE and PSNR. The above graphical representation both for digital and OCT image shows that the required condition of low RMSE and high PSNR is satisfied by the Wiener filter. Therefore, we can say that it is the best filter as compared to other filters for improving the quality of both Digital and OCT images.

REFRENCES

[1] Anil K. Jain, "Fundamentals of Digital Image Processing", Second Edition, NJ Prentice-Hall, 1989.

[2] V. S. Frost, J. A. Stiles, K. S. Shanmugam, J. C. Holtzman", A model for radar image & its application to Adaptive digital filtering for multiplicative noise", IEEE Transaction on pattern analysis and machine intelligence, Vol. PMAI 4, pp.175-166, 1982.

[3] J.S. Lee, "Digital image enhancement and noise filtering by use of local statistics," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 2, no. 3, pp. 165-168, 1980.

[4] Jingdong Chen, Jacob Benesty, Yiteng Huang, Simon Doclo, "New Insights Into the Noise Reduction Wiener Filter", IEEE Transactions on audio, speech, and language processing, vol. 14, no. 4, July 2006.

[5] T. Kailath, "Equations of Wiener Hopf type in filtering theory and related applications", in Norbert Wiener: Collected Works vol. III, P. Masani, Ed. Cambridge, MA: MIT Press, 1976, pp. 63–94.

[6] Brett E. Bouma, Guillermo J Tearney, Handbook of Optical coherence Tomography, New York, Marcell Dekker 2002.

[7] A. Stella, Dr. Bhushan Trivedi, "A Review on the use of Optical Coherence Tomography in Medical Imaging", International Journal of Advanced Research in Computer Science, volume 2, No 1, Jan -Feb 2011, 542-544.

[8] Matlab 6.1 ― Image Processing Toolbox‖,http:/www.mathworks.com/access/helpdesk/help/toolbox/images/.

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