ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

SITES

Smart And Innovative Technologies In Engineering And Sciences

Gyan Ganga College of Technology

Vol. 5, Special Issue 3, November 2016

Analysis of Filters for the Reduction of Speckle Noise in Images

Bhawna Ondela[1], Silky Pareyani[2]

Student, EC Department, Gyan Ganga College of Technology, Jabalpur, India[1]

Asst Professor, EC Department, Gyan Ganga College of Technology, Jabalpur, India[2]

Abstract: This paper represents a novel approach to improve de-speckling in SAR images. The main issue in imaging technique is presence of grainy noise termed as 'speckle', which will affect the overall quality of image, hence it is highly required to use effective speckle reduction techniques to suppress speckle. Various filtering techniques are available to reduce the speckle noise and to enhance the quality of the image. As Speckle noise is multiplicative in nature which is very much difficult to remove. So this paper presents a review on different spatial and transform methods such as spatial domain technique and wavelet domain techniques.

Keywords: Synthetic aperture radar (SAR), speckle noise, statistical parameter.

I. INTRODUCTION

Synthetic aperture radar (SAR) imaging, due to its powerful imaging capability in all weather conditions, day and night, sunny and cloudy, has become more and more popular in our daily lives and in military tasks. But SAR images are corrupted by speckle noise due to random interference of electromagnetic signals. The speckle degrades the quality of the images and makes interpretations, analysis and classifications of SAR images harder. Thus speckle noise should be removed before applying any image processing techniques. Speckle reduction usually consists of three stages. First stage is to transform the noisy image to a new space (frequency domain). Second stage is the manipulation of coefficients. Third is to transform the resultant coefficients back to the original space (spatial domain). In wavelet sub bands noise is present in small coefficients and important feature details are present in large coefficients. If removal of small coefficient is done, we can get a noise free image.

Therefore in recent years wavelet based speckle reduction is becoming a field of interest among researchers for multi resolution decomposition and analysis of image [1]. Many algorithms have been developed for de-speckling, including the Lee filter, the Frost filter, the Butterworth Filter, and Wavelet filter. These standard filters usually perform well in despeckling; however, they typically exhibit limitations in preserving sharp features and/or details of the original image. Thus to preserve edges enhanced directional smoothing is applied. Earlier for reduction of speckle researchers use discrete wavelet transformation .But drawback of DWT is that it is translation variant [10]. Some important coefficients can be lost during transformation from original signal to sub bands. Thus to save coefficients undecimated wavelet transform (UDWT) is used. Basic idea of undecimated wavelet transform is to fill in the gaps caused by decimation step in DWT. UDWT leads to an over-determined and redundant representation of the original data. Whether discrete or undecimated wavelet is used, we need to take care for selecting optimal thresholding. Many thresholding techniques are used by researchers such as hard, soft, Visu Shrink, Sure Shrink, Oracle Shrink, Normal Shrink, Bayes Shrink, Thresholding Neural Network (TNN) etc. But there are some draw backs of using those thresholds. Thus we are using brute force thresholding which gives best results as compared to above threshold techniques.

II. BASIC PRINCIPLES OF SPECKLE THEORY AND FILTERING TECHNIQUE

SPECKLE MODEL:

A realistic model for explaining a SAR image to simply measuring a patch of homogenous area in SAR image can be expressed as

$$I(x, y) = R(x, y). S(x, y) \quad (1)$$

Where

(x, y)- are the spatial range and azimuth co-ordinates of the resolution

I(x, y)- is the intensity of SAR image i.e. degraded pixel of observed image

R(x, y)- is the random process of unspeckled radiance i.e. noiseless image pixel

S(x, y)- is model as speckle noise having stationary random process with unit mean and variance proportional to effective number of looks N.

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

SITES

Smart And Innovative Technologies In Engineering And Sciences

Gyan Ganga College of Technology

Vol. 5, Special Issue 3, November 2016

III. SPECKLE FILTERING TECHNIQUES

There are basically two speckle filtering methods. Both these methods have their own advantages and disadvantages and are adopted according to their specific requirements complexity and performance.

1. Spatial domain technique
2. Wavelet domain techniques

Spatial domain filtering

Spatial domain techniques are widely used in the digital image processing. The term spatial refers to the grid of pixels that represents an image. The relative position and local neighbourhood pixel values are important in spatial domain techniques. So this paper describes some filters for speckle noise reduction.

Transform Domain Techniques

In transform domain techniques firstly the image is transformed into frequency domain than it will transform in to spatial domain and then domain specific properties are exploited to process the image.

In this section several despeckling algorithms are compared for images.

A. Lee filter:

This filter is achieved on (MMSE) Minimum Mean Square Error. It reduces speckle noise by applying a spatial filter that centre pixel intensity in a filter window is replaced with the average intensity values of neighbouring pixels [2].

$$\hat{s}(p,q) = W_{p,q} Z[p,q] + \left(1 - W_{p,q}\right) E\{Z_{p,q}\} \qquad (2)$$

Where E is mean intensity value, $W_{p,q}$ is adaptive filter coefficient and can calculate by formula,

$$W_{p,q} = 1 - \frac{C_N^2}{C_I^2 + C_N^2} \qquad (3)$$

C_N, C_1 are coefficient of variation of the noisy image and Coefficient of variation of the reference image respectively.

B. Low pass Filter:

Low pass filter completely eliminate the component above the cut-off frequency while allow the below unchanged. As speckle is a high frequency content, it can be effectively suppressed by LPF.

$$H(a,b) = \begin{cases} 1 \text{ if } I(a,b) \le I_0 \\ 0 \text{ if } I(a,b) > I_0 \end{cases} \qquad (4)$$

Where I0 is specified positive quantity, point (a,b) is distance from the origin of the frequency plane.

$$I(a,b) = (a^2 + b^2)^{1/2}$$

In this Low pass filter all the frequencies inside the circle of radius Io are passed with no attenuation, whereas all frequencies outside this circle are completely attenuated.

C. Butterworth Filter:

Butterworth filter provides a maximally flat and constant response. The Butterworth low pass filter is an approximation to the ideal filter without some step discontinuous model. The transfer function of the Butterworth filter with order 'n' and cutoff frequency locus at a distance I0 from the origin is defined by the relation,

$$H(a,b) = \frac{1}{1 + [I(a,b)/I_0]^{2n}} \qquad (5)$$

$$I(a,b) = (a^2 + b^2)^{1/2} \qquad (6)$$

D. Mean Filter:

Mean Filter Has the property of locally reducing the variance thus reducing SNR and it requires the user to specify only the size of the window.

However it has the effect of potentially blurring the image. This filter is optimal for additive Gaussian noise whereas the speckled image obeys a multiplicative model with non Gaussian noise. Therefore simple mean is not the optimal choice.

E. Median Filters:

Median Filters are utilized for despeckling due to their robustness against impulsive type noise and edge preserving characteristics. The median filter produces less blurred images. [5]The compounding procedure uses both the mean and median filters.

E. Wavelet filter:

Wavelet filter used to reduce the speckle image with added advantage of edge preservation and feature sharpening ability [2].

$$W_\varphi(x_0,m,n) = \frac{1}{\sqrt{MN}} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} f(i,j)\varphi_{x_0}.m.n(i,j) \quad (7)$$

$$W_\varphi^i(x,m,n) = \frac{1}{\sqrt{MN}} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} f(i,j)\varphi_x^i.m.n(i,j) \quad (8)$$

$W_\varphi(x_0,m,n)$ is approximation coefficient and $W_\varphi^i(x,m,n)$ is horizontal, vertical and diagonal component coefficient.

F. SRAD filter:

SRAD filter is known as speckle reducing anisotropic diffusion. The SRAD can eliminate speckle without distorting useful image information and without destroying the important image edges. The results which are given below tells the SRAD provides superior performance in comparison to the conventional techniques like lee, frost, kaun filters in terms of smoothing and preserving the edges and features.

G. Frost Filter:

The Frost filter is an adaptive filter that uses a negative exponential distribution for the speckle noise and local image statistics for filtering process. This filter gives

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

SITES

Smart And Innovative Technologies In Engineering And Sciences

Gyan Ganga College of Technology

Vol. 5, Special Issue 3, November 2016

weights for each cell by using local image statistics i.e. calculated locally for each filter window. The weight for a cell depends on the distance from the center cell. In order to minimize the mean square error of the signal estimate this filter performs a weighted average of the cell values in the filter window, with the weights for each cell [6]. The filter therefore smoothes more in homogeneous areas because the center cells are heavily weighted as the variance in filter window increases, but provides a signal estimate closer to the observed value of the center cell in heterogeneous areas.

H. Kuan filters:

This filter uses a maximum likelihood probability approach to estimate the true signal value for the center cell in the filter window and assumes that speckle noise has a negative exponential distribution, and maximizes a probability function involving the center cell value, the local mean and standard deviation, and the noise standard deviation. In this filter, the multiplicative noise model is first transformed into signal-dependent additive noise model.

IV. ESTIMATION OF STATISTICAL PARAMETERS

The parameters which are used in the filter performance evaluation are Signal to Noise Ratio (SNR), Root Mean Square Error (RMSE), Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE).

1. Mean square error (MSE):

MSE is used to compare the original and despeckled image. It is defined by difference between the mean square values of original image to filtered image.

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[I(i,j) - \hat{I}(i,j)]^2 \qquad (9)$$

Here M, N are number of rows and columns, reference image MSE value will be zero.MSE value will smaller and larger depends on difference between original image and filtered image[7].

2. Root Mean Square Error (RMSE):

RMSE is an estimator in many ways to quantify the amount by which a filtered/noisy image differs from noiseless image.

$$RMSE = \sqrt{MSE} \qquad (10)$$

3. Signal Noise Ratio (SNR):

Larger Signal to noise ratio indicates better filtering effect, signal to noise ratio is logarithmic mean squared value of original image to mean square error.

$$SNR = 10\log10 \frac{\frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1} I^2(i,j)}{MSE} \qquad (11)$$

4. Peak Signal Noise ratio (PSNR):

PSNR used to measure the performance of the speckle. This is ratio between the logarithmic maximum fluctuations in the input signal to mean square error.

$$SNR = 10\log10 \frac{(2^N - 1)^2}{MSE} \qquad (12)$$

V. EXPERIMENTAL RESULTS

In this section, simulation results are obtained by processing several test SAR and Ultrasound images using filtering techniques and we compare the results with speckle filtering methods. In order to be able to quantify the improvement achieved by our method, we have first degraded original "noiseless" images with synthetic speckle in a controlled manner.

1. PET image:

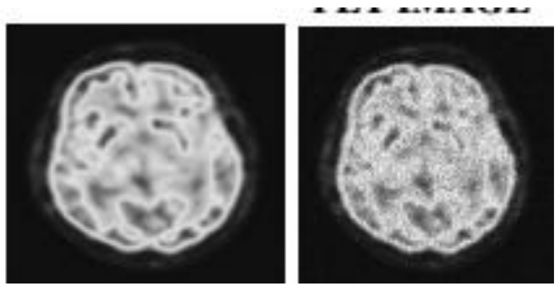

Fig.2 (a)Original PET scan Image (b) Noisy image with SD 0.02,

Table 1: Comparison of different de-noising Filters for PET image Corrupted by Speckle Noise with Variance = 0.02

FILTER	MSE	RMSE	SNR	PSNR
unfiltered	38.2432	6.1841	55.2541	32.3053
MEDIAN	41.1492	6.4148	54.8899	31.9872
WEINER	40.3851	6.3549	54.9679	32.0686
LEE	46.02	6.7838	54.4007	31.5013
KUAN	46.02	6.7838	54.4007	31.5013
FROST	38.9233	6.2389	55.128	32.2287
SRAD	28.2194	5.3122	56.5247	33.6253

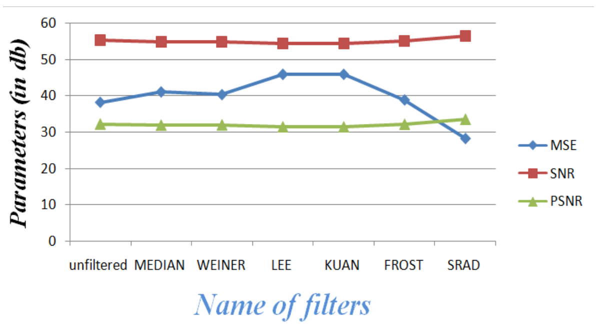

Fig. 3 Graph for Degraded PET Image by Speckle noise with variance 0.02

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

SITES

Smart And Innovative Technologies In Engineering And Sciences

Gyan Ganga College of Technology

Vol. 5, Special Issue 3, November 2016

2. Synthetic aperture radar (SAR) image:

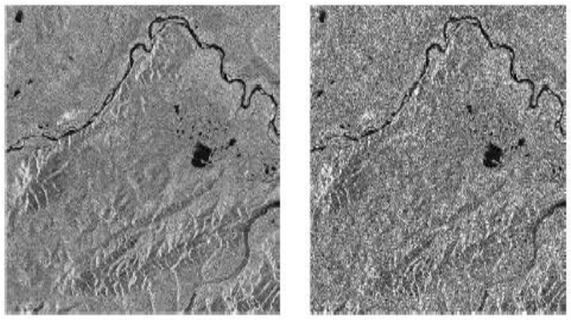

Fig. 4 (a) Original SAR Image (b) Noisy image with SD 0.02

Table 2: Comparison of different de-noising Filters for SAR image Corrupted by Speckle Noise with Variance = 0.02

FILTER	MSE	RMSE	SNR	PSNR
unfiltered	38.2432	6.1841	55.2541	32.3053
MEDIAN	41.1492	6.4148	54.8899	31.9872
WEINER	40.3851	6.3549	54.9679	32.0686
LEE	46.02	6.7838	54.4007	31.5013
KUAN	46.02	6.7838	54.4007	31.5013
FROST	38.9233	6.2389	55.128	32.2287
SRAD	28.2194	5.3122	56.5247	33.6253

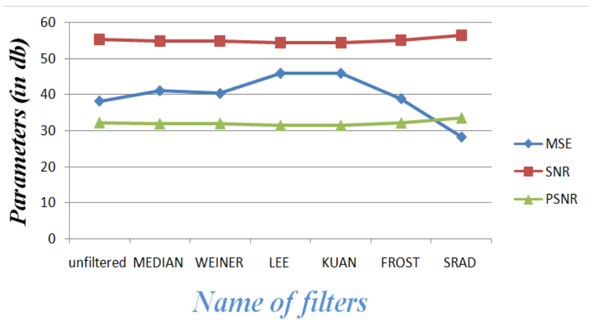

Fig. 5 Graph for Degraded SAR Image by Speckle noise with variance 0.02

In this study both simulation result and speckle image is used to test the performance of despeckling algorithms. In order to compare quantitative evaluation, various filters have been tested Results taken at variance= 0.02 on SAR and PET image. (a) Original image (b) Noisy image and table shown Median filter, Weiner filter, lee filter, kuan filter, forst filter and sard filter. It has been tested for various SAR and PET images. The Numerical parametric of MSE, SNR, PSNR, RMSE are calculated by equation (8), (9), (10) and (11) respectively. The Evaluated results for PET have been tabulated in Tabulation (1) and plotted in fig (2), and (3). Particularly weiner filter shows better performance of SNR in 53.3981, PSNR in 30.466 and minimum MSE of 0.02. Similarly Evaluated results for SAR have been tabulated in Tabulation (2) and plotted in fig (4), and (5). Particularly weiner filter shows better performance of SNR in 54.9679, PSNR in 32.0686 and minimum MSE of 0.02.

VI. CONCLUSION

The use of filter in Digital Image Processing improves the image to a great extent. The model preserves the appearances of structured regions. In case of Synthetic Aperture Radar (SAR) and PET Images, Texture and land surfaces have been enhanced. The performance of the algorithm has been tested using statistical parameter measures. Many of the methods are failures to remove speckle noise present in the Synthetic Aperture Radar (SAR) and PET images, since the information about the variance of the noise may not be able to identify by the methods. The Performance of the Speckle noise reduction model for Synthetic Aperture Radar is well as compared to other filters. Lee filters smoothest the image data, without removing edges or sharp features in the images. Enhanced lee filter and enhanced frost filter divide the image into areas of three classes which are homogeneous area, heterogeneous area and isolated point. In the homogeneous area in which speckle eliminated by averaging the multilook processing, in the heterogeneous area in which speckle are reduced while preserving the texture and preserving texture in isolated point target. Kuan, Enhanced kuan and Gamma MAP filter reduces speckle while preserving edges in SAR images.

REFERENCES

[1] Ruchita Gir, Lalit Jain, Rajesh Rai, "Speckle Reduction of Synthetic Aperture Radar Images using Median Filter and Savitzky-Golay Filter", International Journal of Computer Applications (0975 – 8887) Volume 113 – No. 11, March 2015

[2] R.Vijaya Geetha, Dr. S.Kalaivani, "Quantitative Approach of Speckle Noise Reduction on Synthetic Aperture Radar Images", 2014 IEEE International Conference on Computational Intelligence and Computing Research

[3] Pranali A. Hatwar, Dr. Heena R. Kher, "Analysis of Speckle Noise Reduction in Synthetic Aperture Radar Images", International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181, Vol. 4 Issue 01,January-2015

[4] Ashkan Masoomi, Roozbeh Hamzehyan, and Najmeh Cheraghi Shirazi, "Speckle Reduction Approach for SAR Image in Satellite Communication", International Journal of Machine Learning and Computing, Vol. 2, No. 1, February 2012

[5] Er. Kritika Bansal1, Er. Akwinder kaur2, "A Review on Speckle Noise Reduction Techniques", IOSR Journal of Computer Engineering (IOSR-JCE) e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 16, Issue 3, Ver. I (May-Jun. 2014), PP 74-77

[6] Gopinathan, Poornima, "Enhancement of images with speckle noise reduction using different filters", Int. Journal of Applied Sciences and Engineering Research, Vol. 4, Issue 3, 2015.

[7] K.M. Sharavana Raju1, Mohammad Shahnawaz Nasir2, T. Meera Devi3, "Filtering Techniques to reduce Speckle Noise and Image Quality Enhancement methods on Satellite Images", IOSR Journal of Computer Engineering (IOSR-JCE)

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

SITES

Smart And Innovative Technologies In Engineering And Sciences

Gyan Ganga College of Technology

Vol. 5, Special Issue 3, November 2016

BIOGRAPHIES

Bhawna Ondela received her degree of Bachelor of Engineering in electronic and communication in 2015 from Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, Madhya Pradesh, India. Currently she is pursuing MTECH in digital communication from Gyan Ganga college of Technology, Jabalpur, Madhya Pradesh, India.

Silky Pareyani was born in Jabalpur, Madhya Pradesh, India on 7th march 1987. She received bachelor of engineering degree in Electronics & Communication from Gyan Ganga Institute of Technology & Science, Jabalpur, Madhya Pradesh, India in 2009 and Master of Engineering degree in Communication Systems from Jabalpur Engineering College, Jabalpur, Madhya Pradesh, India in 2012. Currently, she is Assistant Professor in Gyan Ganga College of Technology, Jabalpur and has a teaching experience of 4.5 years.