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RADAR IMAGE PROCESSING USING NON ADAPTIVE FILTER WITH ENHANCEMENT ALGORITHM

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***Abstract* --In image processing, image is corrupted by different type of noises. Synthetic aperture radar images are high resolution images of geographical areas ,moving and stationary objects. The intensities of pixels in these images are based on the spatial orientation, roughness, and dielectric constant of the surface and object imaged. So forming the images are challenging and refining them is difficult. Speckle noise is a significant disturbing factor for SAR image processing. Speckle noise is multiplicative noise, so it's difficult to remove the multiplicative noise as compared to additive noise. So image de-noising has become a very essential exercise all through the diagnosis. In the present work Non Adaptive Filter modified with frost filter has been analyzed to overcome the noise.**

***Index Terms*-- Speckle noise, SAR, Non Adaptive Filter, Frost filter, Enhancement Algorithm (EA), Lee Filter, MMF.**

I. INTRODUCTION

An imaging radar generates a Synthetic Aperture Radar (SAR) image by transmitting a coherent electromagnetic wave and subsequently processing the backscattered signal from the Ground objects. However, due to interference processes between scatters speckle noise is introduced into the image. Speckle noise is a disturbing factor, because it limits the ability to correctly interpret SAR images, restricts edge abstraction, image segmentation, target recognition and classification, and it introduces uncertainty in ground surface parametric inversion (Huang and Liu, 2007). There are two types of speckle noise reduction techniques, according to Lee (1986).Multi-look processing reduces the spatial resolution to improve the radiometric resolution. This simple technique is able to remove speckle noise efficiently, but much edge information is lost. To suppress speckle noise in an uniform area, and to preserve edge information numerous adaptive speckle filter techniques were developed, therefore it is important to apply suitable speckle reduction methods prior to image processing, which are able to smooth speckle noise, while retaining as much detailed information as possible. An image is often corrupted by noise since its acquisition or transmission. The goal of de-noising is to remove the noise while retaining as much as possible the important signal features of an image.

The image analysis process can be broken into three primary stages which are pre-processing, data reduction, and features analysis. Removal of noise from an image is the one of the important tasks in image processing. Depending on nature of the noise, such as additive or multiplicative noise, there are several approaches for removal of noise from an image [1][2]. for example, the Lee filter (Lee, 1980), the Enhanced Lee filter (Lopes et al., 1990), the kuan filter (Kuan et al., 1985), the Frost filter (Frost et al., 1982), the Enhanced Frost filter (Lopes et al, 1990).In this paper a comparison is made between several adaptive speckle filters (Lee, Enhanced Lee, Kuan, Frost, and Enhanced Frost) to investigate their ability to reduce speckle noise, without losing significant detailed edge information. The interest lay in the improvement of SAR images for segregation of different land cover classes (and not on enhancement of within-class texture)[3][4], therefore this research was done on a land cover segment scale .We have minute study and analysis basis performance of these filters was tested with criteria determining the ability of the filter to preserve the mean in an homogeneous land cover segment, suppress the speckle noise and preserve edge information [5][6].

II. IMAGE FORMATION

Basically three operating modes of SAR system [7] Strip map, scan and spot. The most accepted is possibly the strip mode. In this context, the radar antenna point along set location direction with respect to the flight platform path, and the antenna footprint covers a strip on the illuminated surface as platform moves (figure 1).For bi static SAR configuration, the transmitter and the receiver are positioned at different locations in space. If the radar operates as both the transmitter and the receiver, this scenario is called mono static SAR, which is the common practice in most real-world applications present a simplified SAR imaging theory for the mono static case.

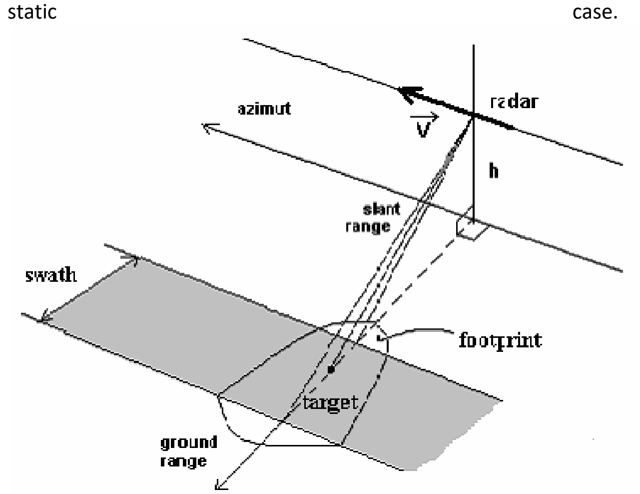

Fig.11 .Antenna footprint

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Since the two dimensional (2D) SAR image is nothing but the display of range profile in one axis and the cross-range profile in the other axis, the scattered field should be collected for various frequencies and aspects (i.e., look angles) to be able to generate the 2DSAR image as steps described in the figure 2, vector is assumed to lie on the 2D plane. Collected data set is generated in the spatial-frequency domains, namely, and. If the back scattered electric field data are gathered within the finite bandwidth of frequencies, B, and within a finite width of angles, Ω, then the 2D data occupy a non- uniform grid in the space. However, if both B and Ω are sufficiently small, the data grid in y space approaches to equally space linear grid. This situation makes it possible to make use of fast inverse Fourier transform in forming the SAR image [8] [9] [10].

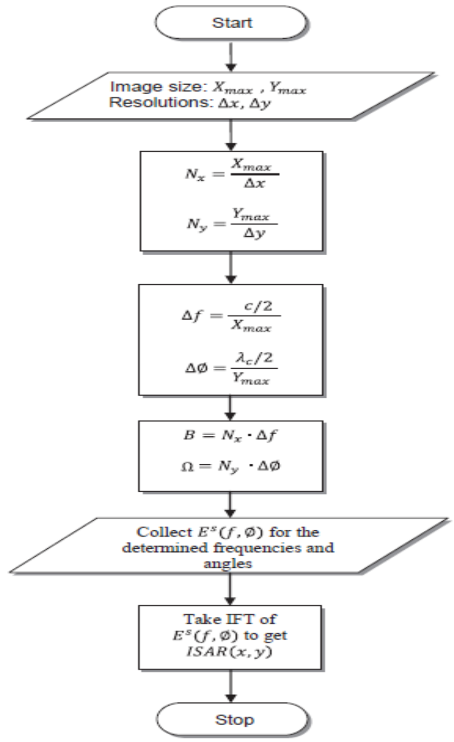

Fig.2 Flowchart for the basic of SAR image formation.

III. MATHEMATICAL MODEL OF NOISE

Mathematically the image noise can be represented with the help of these equations below:

$$V(x, y) = g[u(x, y)] + \eta(x, y) \qquad (1)$$

$$g[u(x,y)]= \iint h(x,y;x',y')u'(x',y')dx'dy' \qquad (2)$$

$$\eta(x, y)=f [g(u(x, y))]\, \eta1(x, y) + \eta2(x, y) \qquad (3)$$

Here *u(x, y)* represents the objects (means the original image) and *v(x, y)* is the observed image. Here *h(x, y; x', y')* represents the impulse response of the image acquiring process. The term *η(x, y)* represents the additive noise which has an image dependent random components *f [g(w)] η1* and an image independent random component *η2*. A different type of noise in the coherent imaging of objects is called speckle noise. Speckle noise can be modeled as-

$$V(x, y) = u(x, y)s(x, y) + \eta(x, y) \qquad (4)$$

Where the speckle noise intensity is given by *s(x, y)*and *η(x, y)* is a white Gaussian noise [1] [8] [11]. The main objective of image-de-noising techniques is to remove such noises while retaining as much as possible the important signal features one of its main short comings is the poor quality of images, which are affected by speckle noise. The existence of speckle is unattractive since it disgraces image quality and affects the tasks of individual interpretation and diagnosis. An appropriate method for speckle reduction is one which enhances the signal-to-noise ratio (SNR) while conserving the edges and lines in the image. Frost filter is one of them.

IV. MODEL OF SPECKLE NOISE

The most critical part of developing a method for recovering a signal from its noisy environment seems to be choosing a reasonable statistical (or analytic) description of the physical phenomena underlying the data-formation process.

The availability of an accurate and reliable model of speckle noise formation is a prerequisite for development of a valuable de-speckling algorithm [12] [13]. In ultrasound imaging, however, the unified definition of such a model still remains arguable. Yet, there exist a number of possible formulae whose probability was verified via their practical use. A possible generalized model of the speckle imaging is

$$g(n, m) = f(n, m)u(n, m) + \xi (n, m) \qquad (5)$$

Where *g, f, u* and *ξ* stand for the observed image, original image, multiplicative component and additive component of the speckle noise basically. Here *(n,m)* denotes the axial and lateral indices of the image samples or, alternatively, the angular and range indices for B-scan images. When applied to ultrasound images, only the multiplicative component of the noise is to be considered; and thus, the model can be considerably simplified by disregarding the additive term, so that the simplified version of (5) becomes

$$g(n, m) = f(n, m)u(n, m) \qquad (6)$$

Homomorphic de-speckling methods take advantage of the logarithmic transformation, which, when applied its converts the multiplicative noise to an additive one.

Denoting the logarithms of *g, f* and *u* by *gl, fl,*and *ul,* respectively, the measurement model becomes

$$g\,1(n, m) = f1\,(n, m)u1\,(n, m) \qquad (7)$$

At this stage, the problem of de-speckling is reduced to the problem of rejecting an additive noise, and a variety of noisesuppression techniques could be evoked in order to perform this task [1]-[14].

V. SPECKLEFILTERING

In speckle filtering a kernel is being moved over each pixel in the image and applying some mathematical calculation by using these pixel values under the kernel and replaced the central pixel with calculated value. The kernel is moved along the image only one pixel at a time until the whole image covered. By applying these filters smoothing effect is achieved and speckle noise has been reduced to certain extent [15].

a. Lee filter [16]- The Lee filter is a standard deviation based filter that calculates the new pixel values with statistics computed within individual filter windows. The lee filter is basically used for speckle lee filter noise reduction. The lee filter is based on the assumption that the mean and variance of the pixel of the interest is equal to the local mean and variance of all pixels within the moving kernel. The formula for the for speckle noise reduction is given as:

$$R(t)= I(t)\, W(t) + I'(t)[1-W(t)] \quad (8)$$

Where, $W(t)= 1- \frac{C^2 u}{C^2\, I(t)}$ (9)

Equation (9) is the weighted function

And $c_u=\frac{\sigma u}{u'}$, $c_1(t) = \frac{\sigma_1 t}{I'(t)}$

are the various coefficients of the speckle u(t) and the image I(t),respectively.

b. Enhanced Lee Filter[17]- The Enhanced Lee filter is an adaptation of the Lee filter and also uses local statistics (coefficient of variation). Furthermore, each pixel is put into one of three classes:
1) Homogeneous class, where the pixel value is replaced by the average of the filter window,
2) Heterogeneous class, where the pixel value is replaced by a weighted average, or
3) Point target class, where the pixel value is not changed.

c. Kuan Filter[18]- In this filter given kaun et al., the multiplicative noise model is first transformed into a signal-dependent additive noise model. Then the Minimum Mean Square Error [MMSE] criterion was applied to this model. The resulting filter has the same form as the lee filter but with the different weighting function which is given as,

$$W(t) = \frac{1- c_{u^2}/\, c_1{}^2(t)}{1+c_{u^2}}$$

Kuan filter is much better than the lee filter.

d. Frost Filter[17]- The Frost filter is an exponentially damped circularly symmetric filter, where a calculation based on the distance from the filter centre[12], the damping factor and the local variance determines the new pixel value.
The implementation of this filter consists of defining a circularly symmetric filter with a set of weighting values M for each pixel,

$$M=e^{-A*T} \quad (10)$$

Where, $A=damp*(V/I^2)$, T is the absolute value of the pixel distance from the centre pixel to its neighbors in the filter window. *damp* is the exponential damping factor, *V* is the variance of the grey level in the filter window, I^2 is the square of the mean grey level in the filter window the resulting grey-level value R for the smoothed pixel is.

$R=(P_1*M_1+P_2*M_2 \ldots\ldots P_N*M_N)/(M_1+M_2 \ldots\ldots M_N)$ Where P_1 .. P_n are grey levels of each pixel in filter window and M_1.. M_n are weights for each pixel.

VI. PROPOSED METHOD

Based on the experiments performed with the existing image enhancement methods, we have decided with an idea of a better method. Accordingly, in this paper we present an idea of Enhancement algorithm with Non Adaptive Filter having properties of adaptive wiener filter, known as frost filter for noisy image[19][20]. The motivation for coming up with this algorithm is to solve the issues with Enhancement Algorithm [21]. In the existing algorithm, the input image is filtered using standard median filter.
Hence it is not able to de-noise the image corrupted with higher density noise. So the final output produced by Enhancement algorithm is not satisfactory. In the proposed method we have integrated the image de-noising algorithm to improve the perceptual quality of an image. In the proposed method, the input (noisy) image is first de-noised using Enhancement Algorithm and then apply the Non Adaptive filter integrated with FCN Frost Filter algorithm, described in the following Figure 3 flow chart. when applied to pictures and videos help the visually impaired in reading small print, using computers, television and face recognition [10]. Several studies have been conducted [7], [22], that highlight the need and value of using image enhancement with noise removal for the visually impaired.

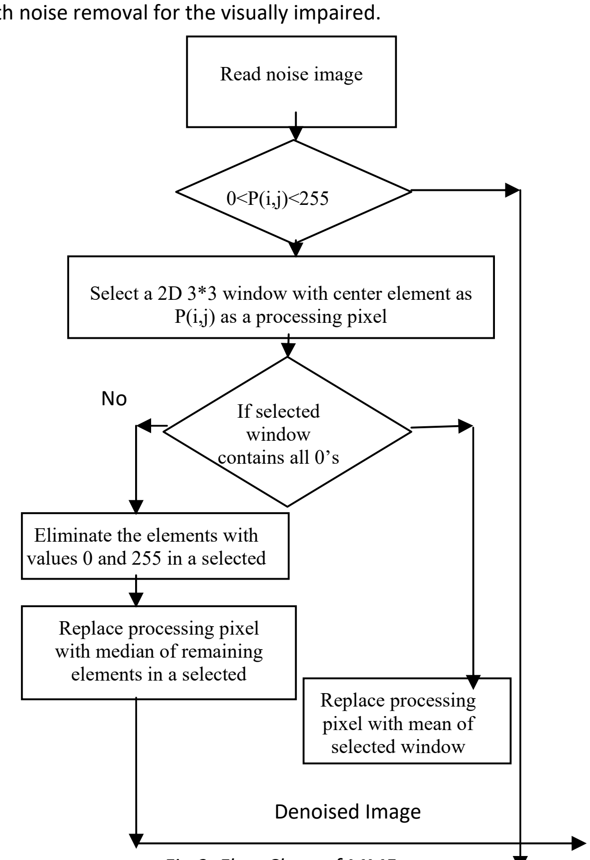

Fig.3. Flow Chart of MMF

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Algorithmic steps for De-noising the Image

1) *Read a Noisy Image and Calculate pixel values.*
2) *Check if Pixel value >0 and <255*
   Then go to step 3 else go to step 4
3) *Apply the generalized Unsupervised masking and Median filter* c = 2.*d-1;

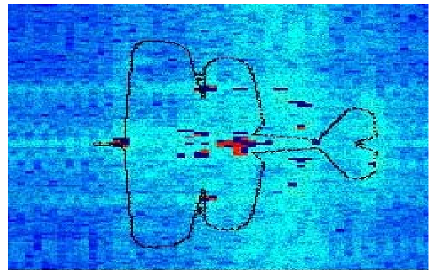
```
gmax = 5;
gmin = 1;
n = 1;
b = (gmax-gmin)./(1-exp(-1));
a = gmax-b;
gd = d;
 for i = 1:SIZEX
       for j = 1:SIZEY
          abs_c = abs(c(i,j));
 g = a + b.*exp(-abs_c)^n;
 d_g = d(i,j)^g;
 one_d_g = (1-d(i,j))^g;
 gd(i,j) = d_g./(d_g + one_d_g);
end
         end
        z1 = (1-z)./z;
        gd1 = (1-gd)./gd;
 v = 1./(1+(z1.*gd1));
```

4) *Apply the Non Adaptive Filter with Frost Filter at each pixel value.*

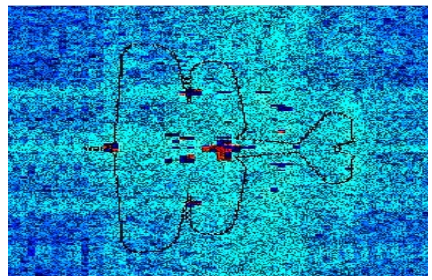
```
[SIZEX SIZEY] = size(x);
      for i = 1:5
       y = fcnFrostFilter(x);
       end
      d = 1./((((1-x)./x).*(y./(1-y)))+1);
      z = adapthisteq(y, 'clipLimit',0.002);
           c = 2.*d-1;
          gmax = 5;min = 1; n = 1;
           b = (gmax-gmin)./(1-exp(-1));
          a = gmax-b; gd = d;
           for i = 1:SIZEX
                   for j = 1:SIZEY
                   abs_c = abs(c(i,j));
                   g = a + b.*exp(-abs_c)^n;
                    d_g = d(i,j)^g;
                   one_d_g = (1-d(i,j))^g;
                   gd(i,j) = d_g./(d_g + one_d_g);
                   end
          end
```

VII. EXPERIMENTAL RESULTS AND ANALYSIS

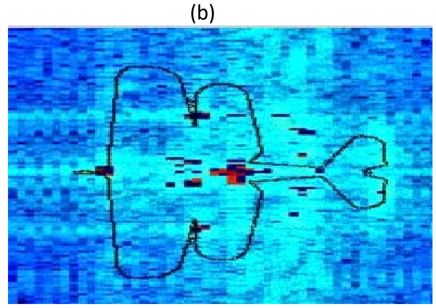
As indicated by the simulation results, the performance of proposed Enhancement algorithm is better on all the parameters. There is a significant increase in Peak Signal to Noise Ratio (PSNR) in each case. The Mean Square Error and Mean Absolute Error are less for proposed algorithm and it verifies that the input images are effectively de-noised.



(a)



(b)

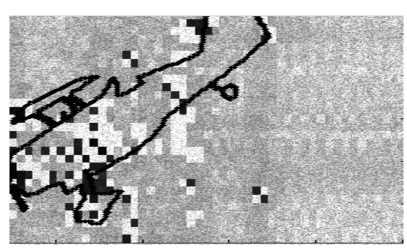


(c)

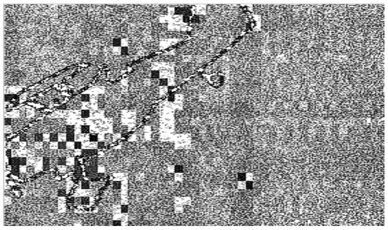
Fig.4(a) Noisy Image with 40% noise density
(b) De-noised Image using EA
(c) De-noised Image using Proposed Method

TABLE-I
RESULT COMPARISON AMONG METHODS FOR VARIOUS NOISE DENSITIES

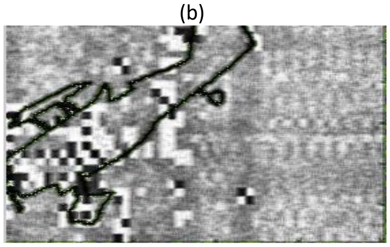
Noise in %	PSNR in dB			
	KUAN Filter	**LEE Filter**	**GUM Median Filter**	**Proposed Method**
30	+48.79	+57.76	+57.79	+60.07
40	+47.38	+56.54	+56.38	+59.41
50	+46.29	+55.46	+55.29	+58.96
60	+45.25	+54.62	+54.25	+58.62
70	+44.42	+53.85	+53.42	+58.35



(a)



(b)



(c)

Fig.5. (a) Noisy Image with 30% noise density
(b) De-noised Image using EA
(c) De-noised Image using Proposed Method

The dataset Images of Figure 4(a) and Figure 5(a) are generated from the given datasets of SAR image formation. Figure 6(a) image acquired from Data Collection Supports Sensors Development, Organization, USA.

(a)

(b)

(c)

Fig.6.(a) Noisy Image with 50% noise density
(b) De-noised Image using EA
(c) De-noised Image using Proposed Method

The dataset pictures used for the experimental analysis, picture figure 4 and picture figure 5 are result of image formation from the real moving object dataset received from Radar monitoring system of USA while the picture figure 6 is satellite image of geographical area. The result table 1 show the analysis of picture figure 4 for various Noise percentage levels.

TABLE-II
RESULT COMPARISON AMONG METHODS FOR VARIOUS NOISE DENSITIES

Noise in %	MAE VALUES			
	KUAN Filter	**LEE Filter**	**GUM Median Filter**	**Proposed Method**
30	0.88	0.78	0.62	0.45
40	0.97	0.83	0.69	0.49
50	1.41	0.86	0.73	0.51
60	2.08	0.89	0.75	0.54
70	2.87	0.92	0.77	0.55

VIII. Conclusion

In this paper, techniques for speckle noise reduction like lee, Kuan filter has been analyzed. Proposed algorithm of Non Adaptive Filter is better than all the filter techniques for removing speckle noise. There is a significant increase in Peak Signal to Noise Ratio (PSNR) by using Non Adaptive Filter technique. The Mean Square Error and Mean Absolute Error are less for proposed algorithm and it verifies that the input images are effectively de-noised. In future, further enhancement can be done by preserving the edges and useful information of an image to get the optimum threshold for removal of speckle noise.

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