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A Survey on Entropy Efficient Model For SAR Image Using BSF with Discrete Wavelet Transform

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Abstract - Multi-temporal synthetic aperture radar (SAR) images have been successfully used for the detection of different types of terrain changes. However, SAR image change detection based on wavelet transform is still restrained from the existence of speckle noise and the nature of wavelet transform. In this paper, an unsupervised SAR image change detection fusion framework based on shearlet transform is proposed. In the proposed method, The Gauss filtering is combined with log-ratio to impair speckle. Then the difference map (DM) of Gauss-log ratio and the difference map of ratio based on Gabor feature are fused with shearlet transform. Meanwhile, DM is decomposed to low frequency image and four high frequency images, different fusion rules are used in multi-scales images respectively, the work of noise reduction is operated with mean filtering. After an inverse shearlet transformation, the final change map can be obtained via a simple OSTU segmentation. The real SAR image pairs in Bern area are used to verify proposed change detection method. The experimental results demonstrate the robustness of the proposed method.

Keyword :- Bivariate Shrinkage, Discrete Fourier Transform, Mean Square Error, Signal to Noise Ratio, Probability Density Function.

I. INTRODUCTION

Over the last two decades, the wavelet transform has become a tool for many research applications. This dissertation aims to design a wavelet based image de-noising method. The major sad drawback of different existing noise reduction methods [1, 3, and 5] is the loss of information.

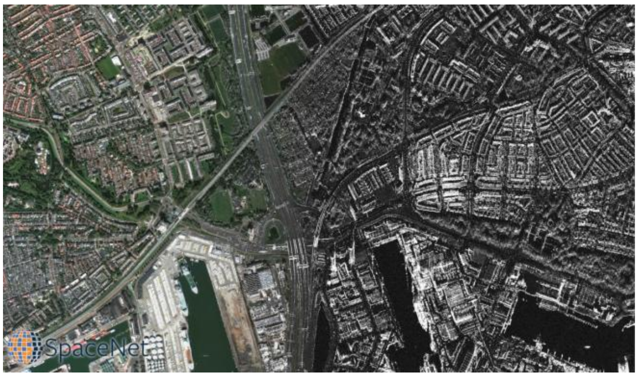


Figure 1.1 Synthetic Aperture Image

This dissertation proposes and compares the methods of speckle noise reduction in Synthetic Aperture Radar (SAR) images. Dissertation deals with the various speckle filters which are based on wavelet based de-noising in SAR images. Present research work is developed in two pass, first existing speckle noise reduction methods are compared and then proposed a simple and efficient hybrid noise reduction methods.

1.1 Segmentation: - In computer vision, image segmentation is the procedure of separating a digital image into multiple segments (sets of pixels, also known as super-pixels). The objective of separation is to streamline and/or alteration the symbol of twin into somewhat that is additional expressive and cooler to examine, conveying a marker to each pixel in an appearance such that pixels with the equal brand portion convinced appearances.

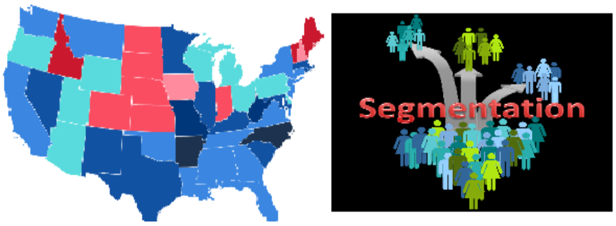


Figure 1.2 Segmentation of world MAP

1.2 Thresholding :- The humblest technique of appearance separation is called the thresholding technique.

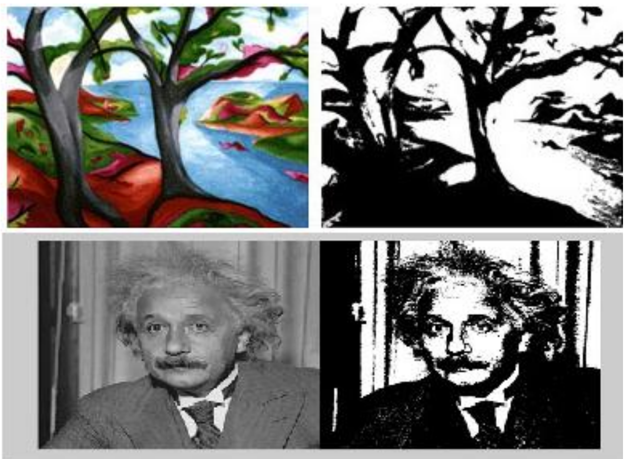


Figure 1.3 Image Thresholding

This technique is founded on a fastener-equal (or a inception worth) to chance a steely-gage appearance keen on a dual appearance. Nearby is too a composed histogram thresholding. The significant of this technique is to choice the inception worth (or standards once several-stages are nominated).

1.3 Clustering Technique - The impartial of group is that arrangement of entities in line with similarities among them, and organizing information into teams. Group performances are between unsubstantiated approaches, they are doing not use previous category identifiers. The most potential of cluster is to find original construction in evidence, not impartial for organization and decoration acknowledgment, except designed for perfect decrease and improvement.

1.4 **K-means Clustering**

K-means grouping is a category of unconfirmed knowledge, which is recycled once you have unlabeled information (i.e., facts devoid of definite classes or collections). The objective of this procedure is to discovery collections in the statistics, with the quantity of collections characterized by the adjustable K.

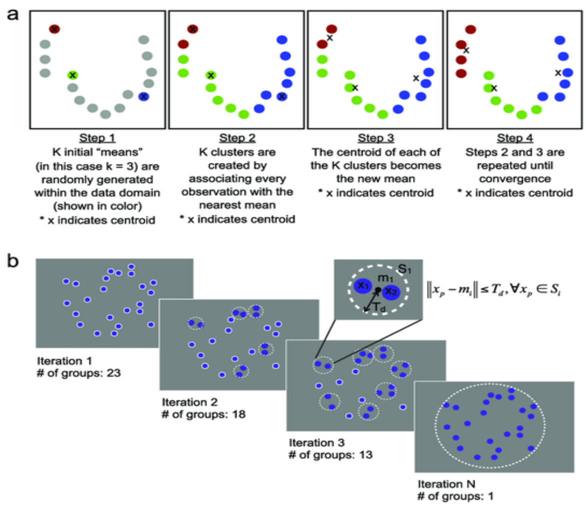


Fig. 1.4 K-Means clustering demonstration

II. LITERATURE REVIEW

This dissertation deals with the study of Synthetic Aperture Radars also abbreviated as SAR systems, which represents the best example of active microwave systems. The initial SAR technology was established in early 1950s. During this era it was demonstrated that the spatial azimuth resolution of the radar system can drastically increased via consistent recording and processing of radar's echoes.

Anutam et al. [17] have carried out an analysis of de-noising filters and wavelet methods. Filtering is done by Mean and Median Filter. And three different wavelet thresholding techniques have been discussed i.e. Universal Thresholding, Bayes Shrink and Visu Shrink. The results conclude that Bayes shrinkage method has high PSNR at the different noise variance and low MSE.

Athira et al. [16] have recovered the clearer version of an image from noisy image using the Dual Tree Complex Wavelet Transform (DT-CWT) and Byes thresholding. The method was seems to be useful for critical applications Viz. remote explorations, satellite imaging, or medical imaging applications [5].

Mean filter is a spatial domain non-adaptive filter [17], which uses the structuring mask or window for filtering. It is also termed as averaging filter. Since every pixel value is replaced by the mean value of all pixels in neighborhood using the structuring window of $M \times M$ size.

Median filter is also a spatial domain non-adaptive filter [17]. In case of median filter, the neighboring pixels are sorted according to brightness and the median value in the neighborhood becomes the new value for the central pixel in a $M \times M$.

J. S. Lee [28], have proposed a noise filtering method by using the of local image statistics. These filters were first proposed in 1981 and then modified in 1986. The basic principle of the filter was estimation of signal using mean square error minimization technique. Filter utilizes the combination of mean filter in homogeneous regions and filtering noisy data in edge regions. Lu, *et al in* 1996 has proposed the modified Lee filter method which performs the speckle noise reduction only in edge regions

D. T. Kuan, *et al in* 1985 have proposed a smoothing filter for images with signal dependent noise model. Kuan in 1987 have proposed a multiplicative noise model which transforms into a signal dependent additive noise model with addition of minimum mean square error criterion.

Anilet et al. [2] have stated that Wiener Filter in the wavelet domain performs better than thresholding methods and Wiener Filter in the Fourier domain. The wiener filter is very efficiently used in many applications such as noise reduction and de-blurring.

Alin et.al. [8] and Paul et. al [3], Anutam et al [17] and TaranjotKaur [30] have designed various filters using several wavelets threshold techniques such as SURE Shrink, Visu Shrink, and Bayes Shrink for efficient image de-noising method. Anutamet. al. [17] have analyzed the performance of various image de-noising methods (lee, kuan, frost etc.) using wavelet thresholding for different decomposition levels.

Manisha et al. [1] have proposed to reduce the noise by Dual-Tree Complex Wavelet Transform based Shrinkage. but method is slightly computationally complex. Anilet et al. [2] have proposed a new image de-noising method which was based on curvelet transform. De-noising of an image is achieved by filtering an image through Wiener filter and using curvelet transform. [2]. Mario et al. [20] have proposed a Kalman's Shrinkage method for wavelet based de-speckling for SAR images. Heng et al. [13] proposed a Bayesian wavelet shrinkage with heterogeneity based adaptive threshold for de-speckling of SAR images based on generalized Gamma distribution.

Bivariate Shrinkage function (Levent et al 2002) is frequently used for the speckle noise reduction in last two decades. Feng et al. [4] have designed a method of SAR image de-speckling via Bivariate Shrinkage based on Direction-let transform domain. Isar, et al. [7] have designed a local adaptive Bivariate Shrinkage function with reduced sensitivity. Levent et al. [6] have used a Bivariate Shrinkage functions for wavelet based d-noising. They have exploited Inter-scale dependency between the wavelet coefficients. They have shown the efficient use of the Bivariate Shrinkage functions for SAR image de-noising.

III. THEORY OF SPECKLE NOISE

3.1 Spatial Domain Methods: The term spatial domain means working on the brightness in the given color space [11]. In this case, the image, it implies working directly with the pixels values or in other words, working directly with the raw data. Let $f(x,y)$ be the original image where f is the gray level value and (x,y) are the image coordinates. An 8 bit image f can take values from $0-255$ where 0 represents black, 255 represents white and all the intermediate values represent shades of color. In a color image of size $256 \times 256 \times 3$, x and y can take values from $(0,0)$ to $(255,255)$ for RGB each color space.

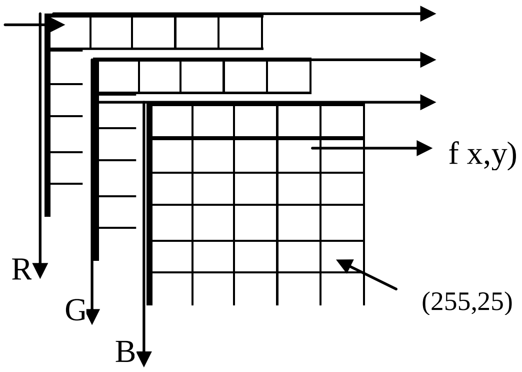


Figure 3.1 Spatial domain representation of color image

3.2 Linear Averaging Filters: An averaging filter is a low pass filter which eliminates the Gaussian noise present in an SAR image. An low pass filtering mask is generated from the spatial response that would give us the averaging filter operation.

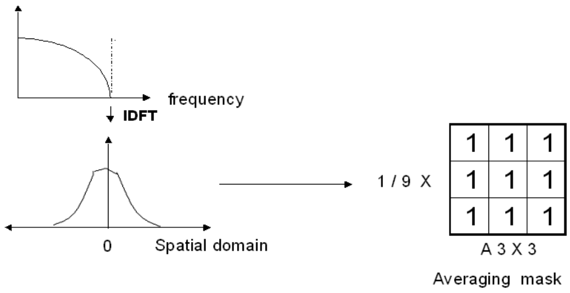


Figure 3.2 Linear low pass averaging filter method

3.3 Median filters : Median filters can perform better to reject certain types of noise, for example “shot” or impulse noise in which some individual pixels have extreme values [17].

For example let us consider the median filter with length of 9, let the input values for the current motion vectors are given as;

$$Gmv_N(t) = sort([\, 124\ 126\ 127\ 120\ 150\ 125\ 115\ 119\ 123\,])$$
Equ.no. 3.2

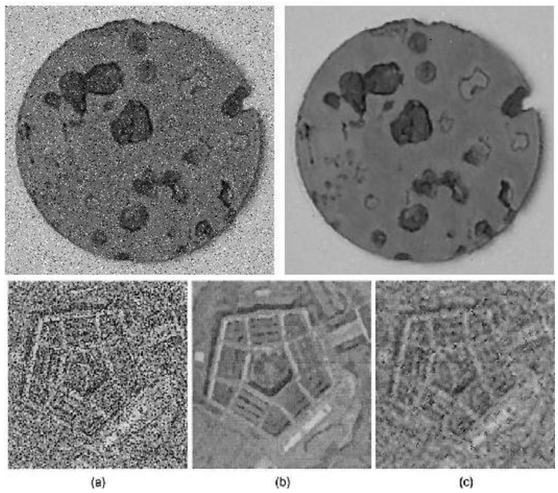


Figure 3.3 Example of Median filter a) NoisySAR_image_2 b) Median filtered image c) improved Image

3.4 Adaptive Weighting Filters

There are many filters which are designed for the Speckle noise reduction in SAR images. These all filters are different than each other in terms of weighting function or in term of threshold selection method. All these methods weights the center pixel value of the filtering mask with a weighting function W, which is calculated.

3.4.1 Lee Filter: Lee [28, 29] filter are based on the Minimum Mean Square Error (MMSE) filtering technique, which results speckle removed image governed by the weighting function [29] given as;

$$Y_{ij} = \bar{K} + W * (C - \bar{K}) \quad \text{Equ.no. } 3.3$$

Where;

Y_{ij} is the Speckle Removed filtered image

$\bar{K}$ is the mean value of the current pixels within the mask

W is the weighting function or matrix

C is the center pixel value of the current mask position

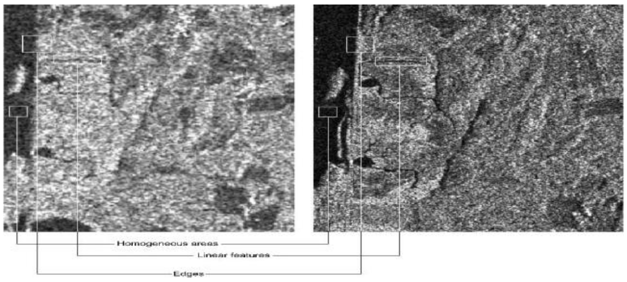


Figure 3.4 Example of Lee filtering a) NoisySAR_image_2 b) filtered image

3.4.2 Kuan Filter The Kuanfilter [18] are modeled as similar to the Lee filters and are widely used for SAR images. these filters are based on the minimum mean square error (MMSE) filtering technique.

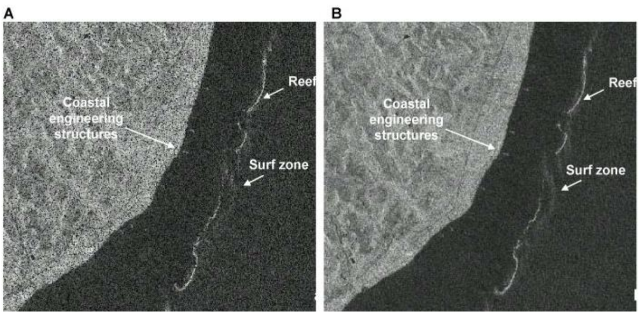


Figure 3.5 Kuan filtering example a) NoisySAR_image_2 b) filtered image

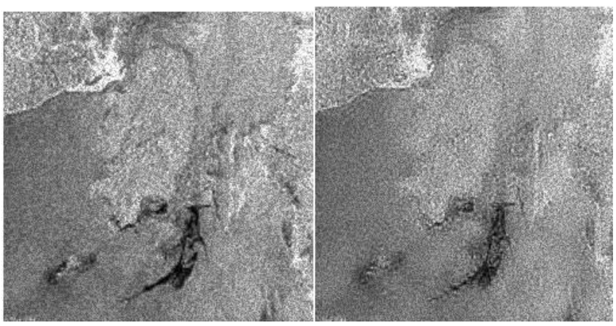


Figure 3.6 Frost filtering example a) NoisySAR_image_2 b) filtered image

3.4.3 Frost Filter: 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 [31]. It replaces the pixel of interest with a weighted sum of the values within the moving kernel and the weighting factors decrease with distance and increase with the increase in variance of the kernel.

3.4.4 Wiener Filter : A 2D wiener filter is used in this dissertation, which uses the neighborhood of $3 \ x \ 3$ mask size. The 2D wiener filter estimates the local mean and variance for neighbourhood of each image pixels [2] using the following equations.

$$\mu = \frac{1}{MN} \sum_{x,y \in p} f(x,y)$$

$$\sigma^2 = \frac{1}{MN} \sum_{x,y \in p} (f(x,y)^2 - \mu^2)$$

Where M =N=3 is the local neighbourhood of pixel. The Wiener filter estimate is generated using the mean and variance estimates as;

$$g(x,y) = \mu + \frac{\sigma^2 - v^2}{\sigma^2} (f(x,y) - \mu)$$

IV. WAVELET SEGMENTATION OF SAR IMAGE

Synthetic aperture radar (SAR) imaging system is usually an observation of the earths' surface. It means that rich structures exist in SAR images. Convolutional neural network (CNN) is good at learning features from raw data automatically, especially the structural features. Inspired by these, we propose a novel SAR image segmentation method based on convolutional-wavelet neural networks (CWNN) and Markov Random Field (MRF). In this approach, a wavelet constrained pooling layer is designed to replace the conventional pooling in CNN.

4.1 Image Fusion :-Land use information is one of the most useful input element in forming policies concerning to economic, environmental issues at national and also at global levels. With the view of these different spectral, temporal and spatial qualified sensors are developed.

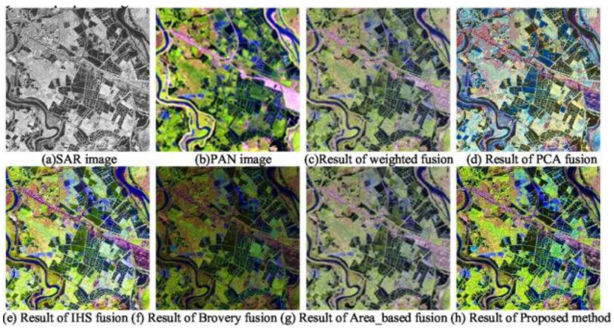


Figure 4.1 Basic Image fusion of SAR Image

4.2 Fourier versus Wavelet Transform Short Time Fourier Transform (STFT) is developed by Gabor (1946), to overcome the problem of Fourier transform. It uses a fixed-size window to analyze the non-stationary signal as shown in Figure 4.3. A small window gives better time resolution and poor frequency resolution, while a large window gives poor time resolution and good frequency resolution. In both cases, the resolution is fixed for high and low frequencies of the signals.

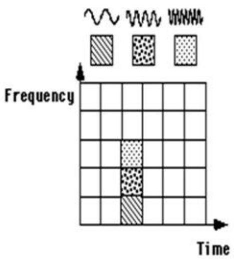


Fig. 1. Fourier basis functions, time-frequency tiles, and coverage of the time-frequency plane.

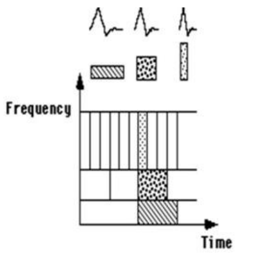


Fig. 2. Daubechies wavelet basis functions, time-frequency tiles, and coverage of the time-frequency plane

It is hard to find the location and spatial distribution of singularities with Fourier transforms. Wavelet analysis is a local analysis; it is especially suitable for time-frequency analysis [34], which is essential for singularity detection. This was a major motivation for the study of the wavelet transform in mathematics and in applied domains.

V. SIMULATION RESULTS & DISCUSSION

The proposed filtering method takes advantage of Frost filtered image and bivariate Shrinkage function based on global thresholding. The results are presented in three stages as results of Wavelet decompositions, Then in the second stage the results of various wavelet based Speckle filters are presented. Finally the results of Wavelet based fusion and qualitative analysis are presented.

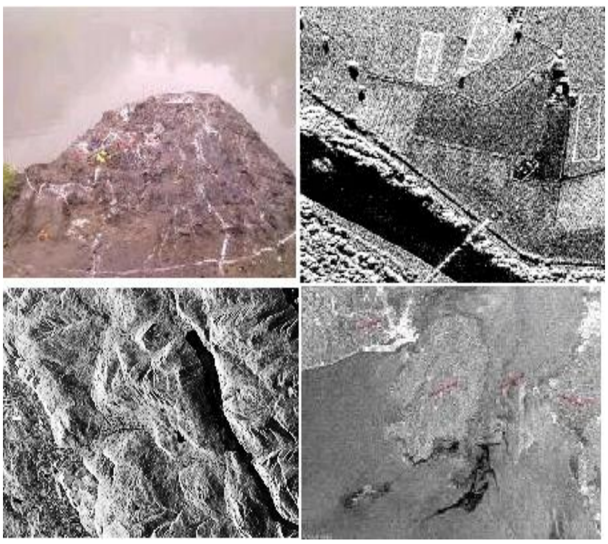


Figure 5.1 Original Sample Image

5.1 Input images : Various 8 bit gray scale and color standard SAR images captured from different environments were used for the performance evaluation of proposed De-noising method. All the images are resized to $256X256$ resolutions for evaluating the performance of the various filtering methods.

7.2 Result of the 2-D DWT Decompositions :-In wavelet based de-noising initially second level DWT is implemented and then on the LL component the filtering algorithm is performed as shown in Figure 6.2-Figure 6.5 for different input images. Finally using the two level inverse DWT the filtered output is generated.

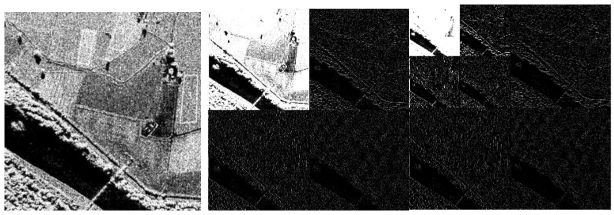


Figure 5.2 Wavelet decomposition for SAR1 imagea) Noisy image b) first level Decomposed image c) Second level Decomposed image

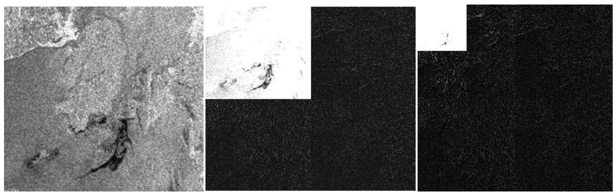


Figure 5.3 Wavelet decomposition for SAR_image_2 a) Noisy image

b) first level Decomposed image c) Second level Decomposed image

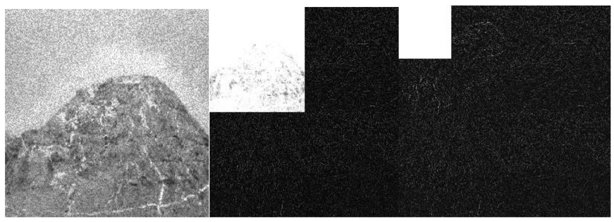


Figure 5.4 Wavelet decomposition for SAR_image_3 a) Noisy image b) first level Decomposed image c) Second level Decomposed image

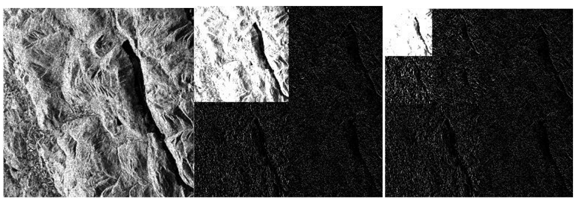


Figure 5.5 Wavelet decomposition for ERS_1 image a) Noisy image b) first level Decomposed image c) Second level Decomposed image

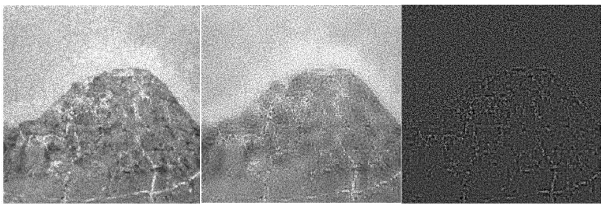
The Haar wavelet is used as wavelet filter for the decompositions. This section presents the our DWT decomposition results level vise for different input images.

it can be seen that the ERS_1 and SAR image 1 are since having more features and therefore are much better represented by the wavelet decomposition levels.

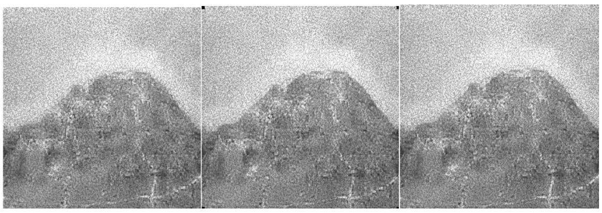
5.2 Comparison of the various SAR Speckle Filters :- This section presents the comparison of the result of the six different speckle noise filtering methods based on the mean square minimization are compared. These spatial speckle reduction filters includes Viz. Lee, Kuan, Frost, Median and Wiener filters. in Figure 7.6- Figure 7.9 successively. The input image is first converted to the gray level image and then speckle noise of variance of 0.02 is added to the image to generate noisy image as shown in Figure 7.6 (b). this image is filtered with different filters as mentioned.

good basis for multiresolution image denoising and de-blurring.[11]

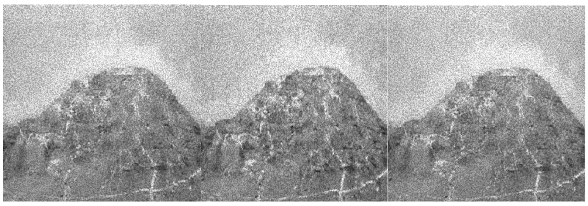
a) original image SAR1 image



a) Noisy SAR_image_3 b) Lee filtered SAR Image c) Kuan Filtered image



d) Frost Filtered image e) Median Filtered image f) Wiener Filtered image



g) Bivariate Shrinkage filter h) BVS fused with Wiener Filtered i) BVS fused with Frost filter

VI. CONCLUSION AND FUTURE WORK

There are following conclusions of our research work.

I. This research work wanted to determine whether suitable Speckle de-noising techniques can be designed to process SAR images, allowing the noise reduction as well as preserving the information within the images for further scientific applications.

II. The increasing use of SAR images creates the demand of processing these images. since mostly the AR images suffers from the presence of Speckle noise. For this reason, it is required to process these images for speckle reduction.

III. While image acquisition is subject to motion between cameras and objects, some controlling algorithm must be required for correcting the geometrical distortions. Due to transmission, de-phasing during reflection, and scattering of radio waves the quality of SAR images are degraded by noise. Therefore, it is requiring to filter the SAR image before extracting any information.

Future Development

In this research work, an image processing method is proposed for reducing the Speckle noise from various kind of SAR images. In future, Further work can be done to design the efficient filter using the combination of different kind of thresholding and Shrinkage techniques for the different SAR images.

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