Speckle Filtering of Microwave C-Band Fine Quad Polarized RADARSAT-2 SAR Image Using Mean and Median Filter

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Abstract— This paper presents a speckle filtering technique for synthetic aperture radar (SAR) image using mean and median filter. SAR image is a type of radar image which can be acquired by satellite at any time; day or night, though there is a change in weather condition or heaviest rainfall. Nowadays SAR image analysis is need of the world in various fields of remote sensing. Speckle noise is the major problem in SAR images which degrades the quality of images. Because of speckle noise the analysis of the image is difficult. The speckle noise can be removed by using different types of filters. Hence the speckle noise reduction helps in preprocessing due to that the overall visibility of SAR image increases, so that processed image is much better than selected original SAR image. In the present work RADARSAT-2 microwave fine quad polarized SAR image dataset having a resolution about 25m and 30 pulses shot is used. In this paper mean and median filters are used as speckle filter. The experimental result demonstrates the comparative study of speckle filter for improving the performance of speckle noise reduction.

Key Words— Mean and Median Filter, Speckle Noise Model, SAR, RADARSAT-2.

INTRODUCTION

SYNTHETIC Aperture Radar (SAR) is an active remote sensing system, which is used to obtain high resolution images. The SAR sensor transmitted signal information towards earth object area and measuring the scattered or reflected energy back from the target material. The SAR has the capacity to penetrate clouds, fog, smoke etc. It is also has the capability to sense the object during the day or night. It operates in all weather conditions, though there is change in environmental changes. The SAR system illuminates a terrain with microwaves and records both the amplitude and the phase of the backscattered radiation, making it a coherent imaging process like in optical system [1]. The wave reflected from the target material consists of contributions from many independent scattering points. Hence, these coherent waves results in the granular pattern of noise known as speckle. The speckle is the multiplicative noise which is the major problem in SAR images and because of such noise the resolution or quality of the image is reduced. Therefore, it is difficult to image processing on SAR images. Usually, due to increasing the power of the signal the speckle noise is also increased by the same amount. Hence it is essential to remove such type of noise from SAR images [2].

For the past two decades, several speckle reduction techniques have been developed for removing speckles and retaining edge details. However, it is still an unresolved problem and in most of the speckle reduction techniques studied by the researchers there is no comprehensive method that takes all the constraints into consideration. The speckle noise is suppressed by applying a speckle removal filter on the digital image before use for further analysis. Masume Rahimi et.al. [3] proposed algorithm for speckle noise reduction of SAR images based on combining the hybrid mean-median filter and SRAD method and from the experimental result, they got high density, smoothing and preserving edges of SAR image. Gajanand Gupta [4] implemented improved median filter algorithm for the de-noising of highly corrupted images and preservation. The result of improved median filter is compared with mean and median filter. Gagnon L et.al. [5] studied comparative result of wavelet coefficient shrinkage (WCS) filter and several standard speckle filters in the radar imaging, including Lee, Kuan, Frost, Geometric, Kalman, Gamma etc. From the results it was found that the WCS filter performs equally well as the standard filters for low-level noise and slightly outperforms them for higher-level noise. Nobuyoshi K. et.al. [6] proposed filter based on the most likelihood estimation filters. They compare the filter result with the local statistical filter. Zhenghao Shi et.al. [7] compare different speckle filter based on objective and practical criteria. In their experimental result, they compare acquired SAR images and computer simulated patterns.

The polarization characteristics of electromagnetic energy recorded by a remote sensing system represent an important variable that can be used in many earth resource investigations [8], [9], [10]. It is possible to selectively send and receive polarized energy using active remote sensing systems which can be in the form of HH, HV, VH, VV polarization. The dynamic range of the like polarized component is larger than that of the cross-polarization component in urban areas; this is in contrast to the measurement of forested areas, where the dynamic range of the cross polarized component is larger than that of the like polarized component [11]. It is also observed that the like-polarization (HH or VV) shows higher reflection and is significantly different from the results observed for cross polarization (VH or HV). In the present study RADARSAT-2 satellite fine quad polarized dataset is used [12].

This paper will provide simulation model result of speckle noise reduction using NEST Version 5.0.16 software. The main objective of the proposed work is to study comparative results of mean and median filter.

SPECKLE NOISE MODEL

In SAR sensing the data is characterized by a typical noise called speckle, which is multiplicative in nature. This is due to inherent techniques used in acquiring the reflected back signal. SAR imaging is based on the integration of a scene coherent response of multiple scatterers from within a resolution cell. This gives rise to constructive and destructive interference of the return signal which in turn gives causes the speckle noise. Thus homogeneous regions will appear non uniform, and edges will lose their sharpness. Such data are not only visually unpleasant, but also unsuitable for image analysis such as classification, segmentation etc. Most of the noise removal techniques used in image processing field deal with additive noise which is generally present in optical data sets [13].

In practice, a digital image generated from the SAR echo returns is represented by spatial variations of pixel intensities over the area. The speckle noise model may be approximated as multiplicative and is given by,

$$Dm, n = Sm, n * Um, n + Vm, n \quad (1)$$

where Dm, n is the noisy pixel, Sm, n represents the noise free pixel, Um, n and Vm, n represent the multiplicative and additive noise respectively and m, n are indices of the spatial locations. Since the effect of additive noise is considerably smaller when compared to that of multiplicative noise, (1) may be written as,

$$Dm, n \approx Sm, n \quad (2)$$

The primary goal of speckle reduction is to remove the speckle without losing the fine details contained in an image. Hence, to achieve this goal filters are used to get better results for terrain classification, target detection and other applications [14].

MEAN AND MEDIAN FILTER

A well understood image enhancement method is linear filtering, which gives a good noise attenuation, but smears the edges and attenuates narrow lines. The performance of linear filtering can be enhanced by optimizing the filter using noise and signal statistics. Another interesting major class of image enhancement algorithms is based on ranked order statistics. The best known of these is the median filter, and in a noise free situation the impulse response of this median filter is zero and the step response is the step signal. On flat regions of the image, median filters attenuate noise in a very similar manner to linear low-pass filters. However, in the neighbourhood of edges the output of the filter becomes more and more prone to large changes in the direction of the edge as the filter slides over the edge [14].

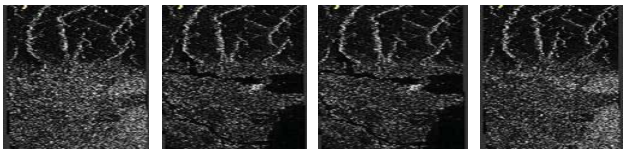
Mean Filter

Mean filtering [15] is a simple, intuitive and easy to implement method of smoothing images, i.e. reducing the amount of intensity variation between one pixel and the next. It is often used to reduce speckle noise in SAR images. The idea of mean filtering is simply to replace each pixel value in an image with the mean value of its neighbours, including itself. Mean filtering is usually thought of as a convolution filter. Like other convolutions, it is based around a kernel, which represents the shape and size of the neighbourhood to be sampled when calculating the mean. Often, a 3×3 square kernel is used, although larger kernels (e.g. 5×5 squares) can be used for more intense smoothing.

Median Filter

Order-statistics filters [16], [17] are nonlinear spatial filters whose response are based on ordering (ranking) the pixels contained in the image area encompassed by the filter, and then replacing the value of the center pixel with the value determined by the ranking result. Median filter is used in the SAR filters & textures program. Sometimes, to get better image quality, it may be useful to filter the same image two or three times. The median filter not only removes the noise also the blurred effect in the SAR image.

STUDY AREA



(a) (b) (c) (d)

Figure. 1 Original RADARSAT-2 SAR Image (a) HH_Polarization (b) HV_Polarization (c) VH_Polarization (d) VV_Polarization

The study area is located in the city of British Columbia with latitudes 49°15′ and longitudes 123°6′ of Vancouver, Canada. This is a coastal seaport city on the mainland of British Columbia, Canada. The 2011 census recorded 603,502 people in the city, making it the eighth largest Canadian municipality. The Greater Vancouver area of around 2.4 million inhabitants is the third most populous metropolitan area in the country and the most populous in Western Canada. The City of Vancouver encompasses a land area of about 114 square kilometers, giving it a population density of about 5,249 people per square kilometer (13,590 per square mile).

The RADARSAT-2 image with the fine quad 2 polarization obtained on 15/04/2008 is used in this study (Figure 1). The SAR image has a full polarization of HH, HV, VH, VV having 30 short pulses [18]. RADARSAT-2 provides powerful new capabilities which include high resolution imaging, flexibility in selection of polarization, left and right-looking imaging options, shortened programming, processing and delivery timelines, superior data storage and more precise measurements of spacecraft position and attitude. MDA Geospatial Services operates the satellite and ground segment, and holds the worldwide distribution rights to RADARSAT-2 products. Data processing included radiometric calibration, geometric calibration, slant range to ground range, reprojection and speckle filtering. In the present work RADARSAT-2 SAR image dataset is used [19], [20].

RESULT & DISCUSSION

The speckle noise filtering is carried out for a RADARSAT-2 SAR image using the different standard speckle reduction filters like mean and median filter. The simulation carried out in NEST Version 5.0.16 software. The performance of both filters in terms of backscattering signal sigma0 for HH, HV, VH, VV window size and area covered in SAR image are compared in Table 1.

The performance of the mean speckle filter with the processing

of sigma0 for HH, HV, VH, VV polarization in the order of 3x3, 5x5 and 7x7 window size RADARSAT-2 SAR image as shown in following figure 2,

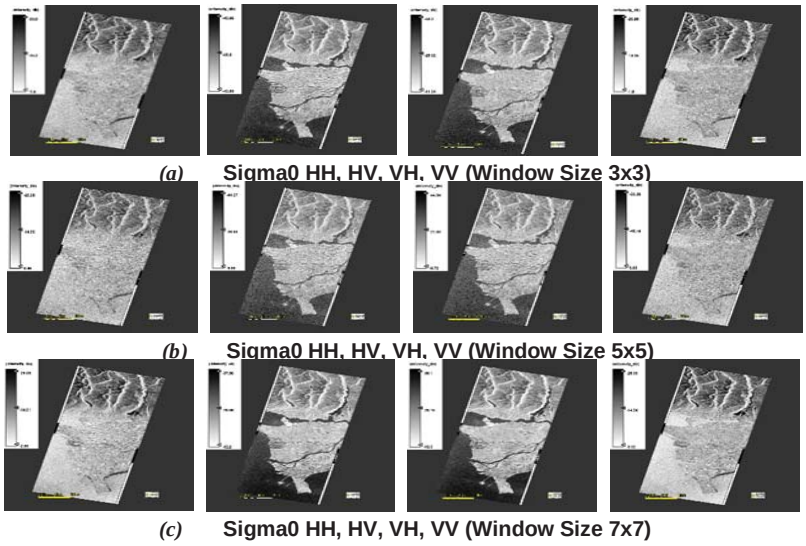


Figure. 2 Sigma0 of Mean Filter SAR Image for Window size (a) 3x3 (b) 5x5 (c) 7x7

It is found that the result of the mean filter as window size of the image increased in the order of 3x3, 5x5, 7x7 the noise reduction level of area 1, area 2 in SAR image is increased. But the noise reduction level of area 3 in SAR image is reduced. The simulation result of cross polarization sigma0 VH & sigma0 HV are nearly same.

Similarly, the performance of the median speckle filter with the processing of sigma0 for HH, HV, VH, VV polarization in the order of 3x3, 5x5 and 7x7 window size RADARSAT-2 SAR image as shown in following figure 3,

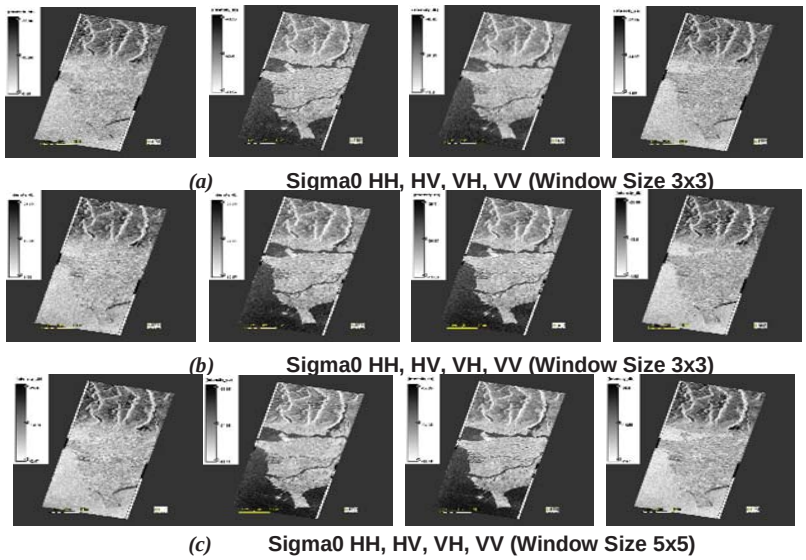


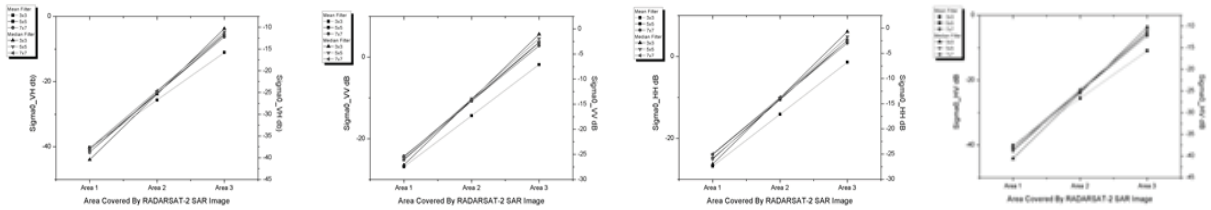
Figure. 3 Sigma0 of Median Filter SAR Image for Window size (a) 3x3 (b) 5x5 (c) 7x7

In the median filter result also the noise reduction levels are increased as window size is increased.

Using the Table 1, the following figure 4 shows sigma0 (dB) response and area covered by the RADARSAT-2 SAR image for all polarizations. From the graphical result the noise removal of sigma0 for all polarizations of area 1 and area 2 is better in median filter. Also the noise reduction is slightly decreased in median filter as compare to mean filter. So from all the above simulation results it is found that the noise reduction of median filter is much better than mean filter.

Table. 1 Sigma0 for HH, HV, VH, VV for 3x3, 5x5, 7x7 Window Size

Sigma0 (dB)	Sigma0_VH			Sigma0_VV			Sigma0_HH			Sigma0_HV		
Window Size → Area (MEAN FILTER) ↓	3x3	5x5	7x7	3x3	5x5	7x7	3x3	5x5	7x7	3x3	5x5	7x7
Area 1	-40.197	-38.692	-38.079	-26.882	-26.04	-25.361	-26.798	-25.867	-25.084	-40.063	-38.623	-37.960
Area 2	-25.620	-25.213	-25.148	-14.341	-14.369	-14.341	-14.100	-14.145	-14.007	-25.495	-25.170	-25.082
Area 3	-11.043	-11.734	-12.199	-1.801	-2.697	-3.320	-1.402	-2.423	-2.930	-10.928	-11.716	-12.203
Area (MEDIAN FILTER)												
Area 1	-40.450	-38.700	-37.846	-27.094	-25.879	-25.496	-26.989	-25.967	-24.997	-40.561	-38.870	-37.952
Area 2	-25.374	-24.866	-24.652	-14.071	-13.897	-14.082	-13.840	-13.850	-13.735	-25.402	-24.920	-24.682
Area 3	-10.298	-11.032	-11.457	-1.048	-1.916	-2.667	-0.691	-1.734	-2.474	-10.243	-10.971	-11.412



(a) Sigma0_VH dB Vs. Area (b) Sigma0_VV dB Vs. Area (c) Sigma0_HH dB Vs. Area (d) Sigma0_HV dB Vs. Area

Figure. 4 Graph of Sigma0 vs. Area for 3x3, 5x5, and 7x7 Window Size of Mean and Median filter SAR image.

CONCLUSIONS

In this paper, speckle filtering techniques have been used to remove the speckle noise from the RADARSAT-2 SAR image. The both mean and median filter used calibrated RADARSAT-2 SAR image. The noise removal depends on window size. In the present work the window size varied in the order of 3x3, 5x5, 7x7 and it was found that the median filter provides better performance than mean filtering techniques in SAR images. This paper provides the proper techniques for specific speckled noisy images.

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