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Comparative Study of Gaussian and Box-car Filter of L-Band SIR-C Data Image using Pol-SAR for Speckle Noise Reduction

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Abstract

The microwave Synthetic Aperture Radar (SAR) is a type of active remote sensing. Image filtering is very important field in SAR image processing. Synthetic Aperture Radar (SAR) data are affected by speckle noise. The speckle appearing in SAR image is due to the interference reflected waves. This noise complicates the problem of interaction of the image by reducing the exactitude of information. That is why speckle reducing is necessary before image analysis because speckle filtering of SAR image has a great impact on the accuracy. This paper proposes comparison between Gaussian and Box-car filter to remove speckle in SAR image. The results of both filters are analyzed and the implication of statistical parameters is compared. The overall process is applied on microwave radar frequency L-band Quad Pole SIR-C Pol-SAR dataset of Cerro Laukaru, Chile near snow cover at Otztal is used.

Keywords: Synthetic Aperture Radar (SAR), Polarimetric SAR (Pol-SAR), speckle noise, Gaussian filter and Box-car Filter.

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1. Introduction

The microwave SAR is an active remote sensing system (Jensen, 2014), which acquired very high resolution images of the Earth. It has its own energy source for illumination. It receives the radiation reflected from the target on the ground surface.It enables observation in all types of weather condition, day and night.It has the capacity to penetrate through clouds, fog, smoke etc. though there is change in environmental changes and capable to sense the object on the Earth. In the present study Microwave L-band Quad Pole SIR-C Pol-SAR dataset is used. The objective of these works is to reducing Speckle noise SAR image using the Gaussian and Box-car filter & analyzed the filtered image on the basis of statistical parameters. The statistical parameters *Viz.*,Mean, Standard Deviation, Coefficient Variance and ENL. This paper will provide comparative simulation model result of both filters using Pol-SAR-Pro Ver. 5.0 and NEST Ver. 5.0.16software. The both software's are freely available on the internet developed by ESA.

2. Preliminaries

Gaussian Filter:

Gaussian filtering is more effective at smoothing images and it used to blur images and remove noise and detail. In one dimension, the Gaussian function is: $G(x) = (1/\sqrt{\pi\sigma^2})\, e^{(x2/2\sigma2)}$. The Gaussian filter is a non-uniform low pass filter. It might not preserve image brightness. When working with images, need to use the two dimensional Gaussian function. $G(x, y) = (1/2\pi\sigma^2)\, e^{(x2+y2/2\sigma2)}$. Where, σ is the standard deviation of the distribution. It is a symmetric function. The Standard deviation of the Gaussian function plays an important role in its behavior. The Gaussian function is used in numerous research areas:

– It defines a probability distribution for noise or data.
– It is a smoothing operator.
– It is used in mathematics [3].

Figure 2shows intensity image obtained using a (3×3) Gaussian filter.

Box Filter:

It is a simple averaging filter that replaces the center pixel in a square kernel by the mean value of kernel pixels. Box filter has a good performance in reducing speckle in homogeneous area. Because of dealing similarly with all pixels in a kernel it degrades spatial resolution and also destroys the polarimetric properties [4]. Figure 2(a), (b), (c) shows intensity image obtained using a boxcar filter. This image shows enhanced contrast and lower random aspect. As it can be seen, the boxcar filter is characterized by two main limitations:

- Sharp edges are generally blurred.
- Point scatterers are over filtered and transformed to spread targets [5].

3. STUDY AREA:

The study area is located in Cerro Laukaru, Chile nearsnow cover at Otztal, With center latitude49°19'12.00"S and longitude 73°27'03.60"W. The dataset is quad polarized with HH/HV/VH/VV polarization. The incident angle is 39.65 and date of acquisition is 04/12/1994. It is nearsnow cover at Otztal.The SAR dataset region of the study area is shown in Figure 1.

Figure 1: SIR-C data image of Band-1, Band-2 and Band-3

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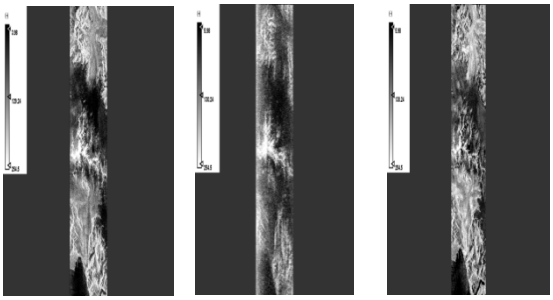
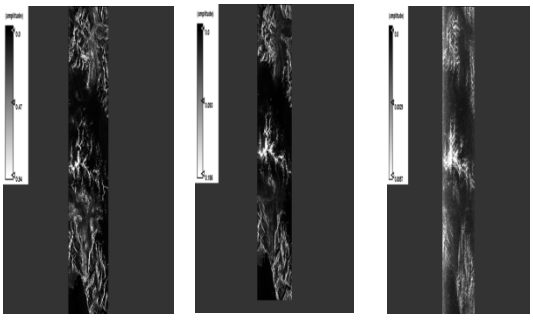


Band-1 Band-2 Band-3

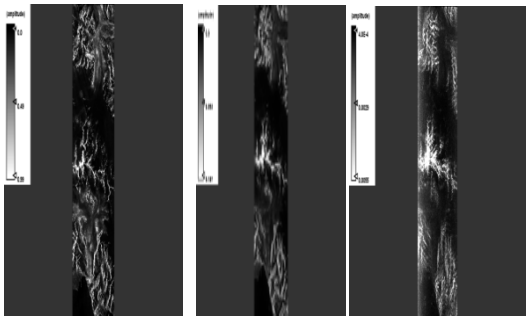
All of the raster channels in the input image are filtered independently. Here raster size of input band is 1178 ×4000. Boxcar filtering is used to increase the effective number of looks (ENL) in the data. This step requires a minimum ENL that is higher than the ENL of the input data.

Figure 2:
Gaussian filtered image of band-1 for T11, Band-2 for T22 and Band-3 for T33



Band-1(T11) Band-2(T22) Band-3(T33)

Figure 3:
Box-car filtered image of Band-1 for T11, Band-2 for T22 and Band-3 for T33.



T11T22T33

4. Statistical Parameter:

Standard Deviation (SD):

The standard deviation (σ) is a measure that is used to quantify the amount of variation/ dispersion of a set of data values.A low standard deviation indicates that the data points tend to be close to the mean (also called the expected value) of the set, while a high standard deviation indicates that the data points spread out over a wide range of values. The standard deviation is commonly used to measure confidence in statistical conclusions.

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

Coefficient of Variation (CV):

This is also called as Standard deviation to mean ratio (SD/M)which is well known quantitative measure for evaluating the level of smoothing in homogenous area. Lower value of CV represents good speckle noise reduction.CV = $\sqrt{[\hat{x}]} / [\hat{x}]$.

Mean Square Error (MSE):

Mean Square Error is defined as (x, x') = E $[(x- x')^2]$ Where x and $\hat{x}$ represents original and filtered images respectively, [·] denotes statistical mean. The highest value of MSE represents original and filtered images are not similar

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and lowest value represents better image quality of the filtered image. MSE based measurements are useful to obtain a global performance assessment on the whole image, but usually they yields little information about the preservation of specific features, for which other indexes can be used.

Equivalent Number of Looks (ENL):

The equivalent number of looks (ENL) was applied to measure the degree of suppression, which was defined as the square ratio of the mean to the standard deviation values in a homogeneous region. The larger the ENL was, the better the quality of the speckle reduction was. The ENL is another good indicator to show speckle noise reduction. The ENL for intensity image is defined as$ENL\ (I) = 1/\beta^2$ and for amplitude image is defined as$ENL\ (A) = (0.522/\beta)^2$

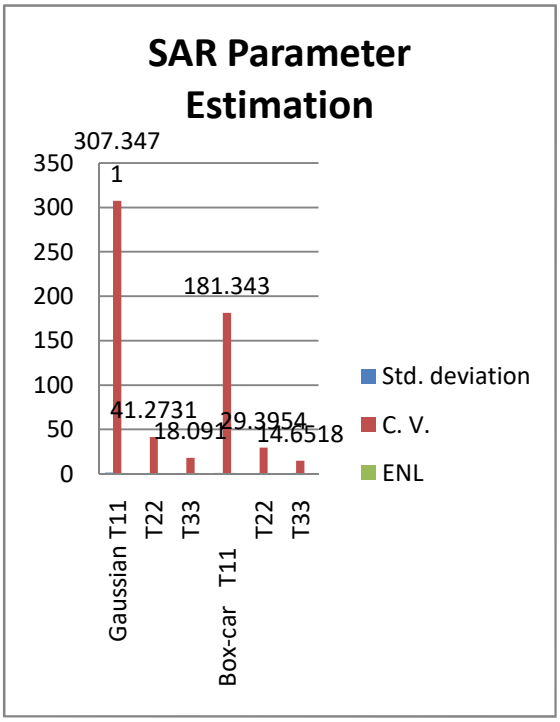

Table:

Filter\ statistics	Mean	Median	Std. deviation	C. V.	ENL
Gaussian T11	0.0703	0.0000	1.3294	307.3471	0.0000
T22	0.0273	0.0000	0.1924	41.2731	0.0006
T33	0.0016	0.0007	0.0032	18.0910	0.0031
Box-car T11	**0.0919**	-0.0000	1.0545	181.3430	0.0000
T22	0.0301	0.0000	0.1757	29.3954	0.0012
T33	0.0017	0.0009	**0.0030**	**14.6518**	**0.0047**

The accuracy assessment results of the speckle noise reduction using Gaussian and Box-car filter implemented on SIR-C Pol-SAR dataset of Cerro Laukaru, Chile on the basis of statistical parameter.

Figure 4: Graph for SAR statistical parameter of Gaussian and Box-car filter for Cerro Laukaru, Chile SIR-C SAR image.

5. Conclusion

In this paper comparison between Gaussian and Box-car filter to remove speckle in multi-look SAR image of Cerro Laukaru, Chile near snow cover at Otztal is used. The results of both filters are analyzed and the implicated of statistical parameters it includes Mean, Median, Standard Deviation, Coefficient Variance and Equivalence Number of Looks (ENL) are compared. Evaluated the performance

of statistical parameter of these filters, they are computedand provided comparative simulation model results of both filters using Pol-SAR-Pro Ver. 5.0 and NEST Ver. 5.0.16software. In figure 1 show the Band-1, Band-2 and Band-3 of SIR-C input data image and figure 2 & 3 shows the result of Gaussian and Box-car filtered images resp. of Band-1 for T11, Band-2 for T22 and Band-3 for T33. Ideally, mean should be close to unity and standard deviation should be as low as possible, Lower value of CV represents good speckle noise reduction and the higher value for ENL represents good noise reduction technique for a well performing filter. Here using the table conclude that Mean close to unity (0.0919) of T11, low Std. deviation(0.0030) of T33, lower Coefficient Variance(14.6518) of T33 and higher value ENL(0.0047) of T33 image, then conclude that the Box-car filter is better than the Gaussian filter.

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