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Research Article

COMPARATIVE STUDY OF GAUSSIAN AND BOX-CAR FILTER OF TERRASAR-X 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. It has its own energy source for illumination. It receives the radiation reflected from the target on the ground surface. It generates a very high resolution imagery of the Earth. It enables observation in all types of weather condition, day and night capabilities. 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. It includes Mean, Median, Standard Deviation, Coefficient Variance and Equivalence Number of Looks (ENL). The overall process is applied on microwaveradar frequency X-band Dual Pole (HH/VV) TerraSAR-X of Sanchagang China; Pol-SAR dataset is used.

INTRODUCTION

The microwave SAR is an active remote sensing system (Jensen, 2014) rather (2), which acquired very high resolution images of the Earth. 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 during the day or night. PolSARpro supports a variety of space-borne and airborne sensors and implements a wide range of algorithms and techniques for SAR data analysis. It is designed to integrate well into a wide variety of other software tools like ASF Map-Ready, NEST and Google Earth [7]. In the present study Microwave space-born TerraSAR-X Pol-SAR dataset is used. The objective of these works is to reducing Speckle noise SAR image using the Gaussian filter and Box-car filter & analyzed the filtered image on the basis of statistical parameters. The statistical parameters *Viz.,* Mean, Standard Deviation, Coefficient Variance and Equivalence Number of Looks. 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.

Polarimetric SAR Data Speckle Filters

Filtering is a technique to remove unwanted signal/noise to get desired signal in an image. Speckle in synthetic aperture radar (SAR) images is due to the coherent interference of waves reflected from many elementary scatterers. This effect causes a pixel-to-pixel variation in intensities and the variation manifests itself as agranular noise pattern in SAR images[7]. Most of the geophysical media, as for the instance: rough surfaces, vegetation ice, snow, etc. have a very complicated structure and composition. Consequently, the knowledge of the exact scattered electromagnetic field, when illuminated by an incident wave, is only possible if the complete description of the scene was available. This type of description of the scatterers is unattainable for practical applications. The

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alternative is to describe them in a statistical form [9]. To removing noise signal, enhance the edge without changing information and preserve texture and also provide a good visual appearance using speckle filter. Apply a mathematical calculation, the kernel window moves also substitutes the value of the window central pixel. As a result, the smoothing effect and visual appearance reduced speckle is achieved [1]. The main objective of the present work is to provide a comparative study of Pol-SAR speckle noise filters with the intention to find the strengths of the different approaches. The objective is not provides the details information of filtering, but only the filtering principle on which it is based on. Here used some (3×3) speckle filters:

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 is 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.

When processing with filter then created directory and it contain the polarimetric datasets to be filtered. Figure 2 I11(c), I22 (d) shows 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. This 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 [5]. Figure 3I11 (e), I22 (f) 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 [8].

Study Area

The study area is located in China,
Location: Sanchagang China
File Format: Geo Tiff
Projection: UTM, WGS 84
Acquisition Mode: Strip-map
Polarization Mode: Dual
Polarization Channel: HH/VV
Orbit: Descending
Angle of Incidence: 30,5
Date: 01/01/2008

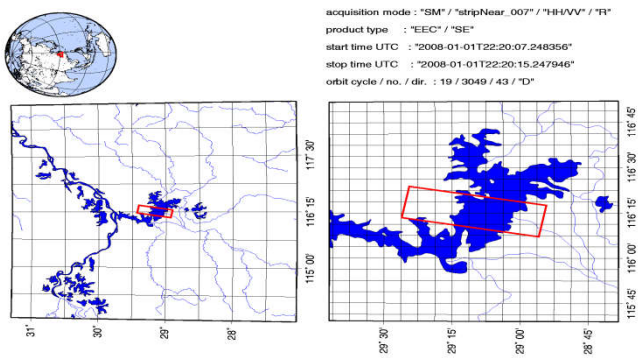
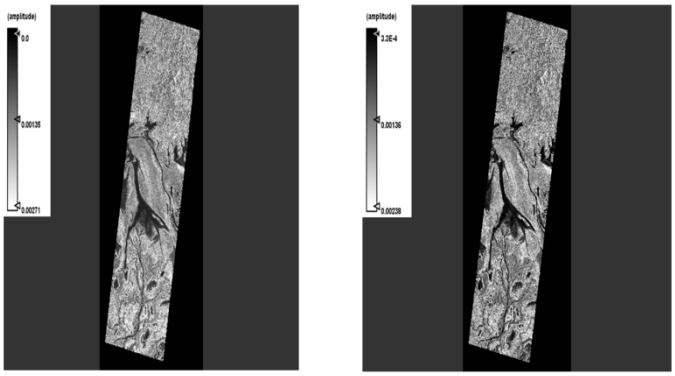


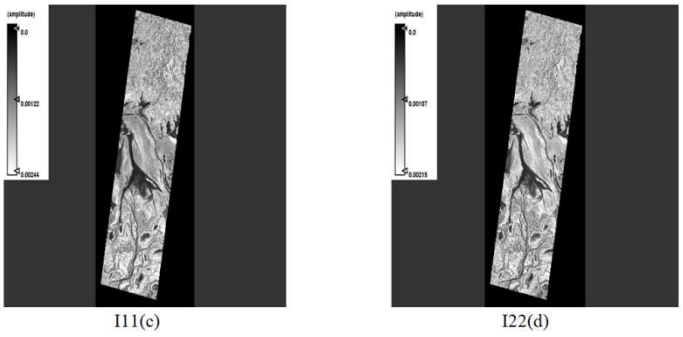
Figure 1 a



I11 (a) **I22 (b)**

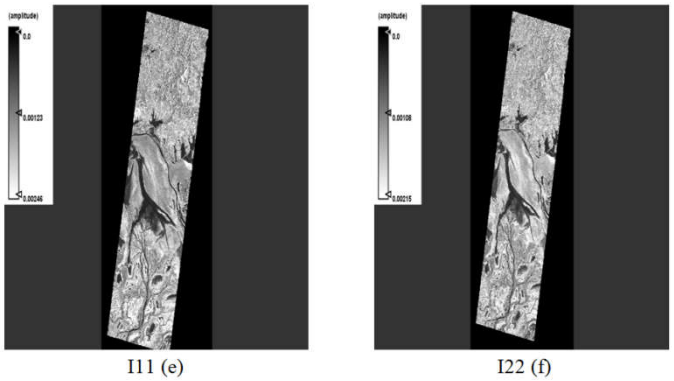
Figure 1b TerraSAR-X data image of I11 for HH Polarization and I22 for VV Polarization.

Figure 1 The SAR dataset region of the study area Sanchagang china is shown in figure 1(a) and the image in figure 1(b).



I11(c) I22(d)

Figure 2 Gaussian filtered image of I11 for HH Polarization and I22 for VV Polarization.



I11 (e) I22 (f)

Figure 3 Box-car filtered image of I11 for HH Polarization and I22 for VV Polarization.

Statistical Parameters

Standard deviation

The standard deviation is commonly used to measure confidence in statistical conclusions. In the standard deviation, quantify the amount of variation of a number (set) of data values. A low standard deviation represent that the data points tend to be close to the mean/ expected value of the set and a high standard deviation represent that the data points are spread out over a wide range of values.

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

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$(\hat{x},) = E [(x - \hat{x})^2]$Where x and $\hat{x}$ represents original and filtered images respectively, $[\cdot]$ denotes statistical mean. The highest value of MSE indicates original and filtered images are not similar and low value indicates the 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 The accuracy assessment results of the speckle noise reduction using Gaussian filter and Box-car filter implemented on TerraSAR-X dataset of Sanchagang, Chinaon the basis of statistical parameter.

Filter\statistics	Min.	Max.	Mean	Median	Std. deviation	C. V.	ENL
Gaussian I11	-0.0000	0.0687	0.0008	0.0004	0.0009	2.8090	0.1267
I22	-0.0000	0.0192	0.0008	0.0005	0.0008	1.5337	0.4251
Box-carI11	-0.0000	0.0739	0.0008	0.0004	0.0009	3.0399	0.1082
I22	-0.0000	0.0201	0.0008	0.0004	0.0008	1.5647	0.4084

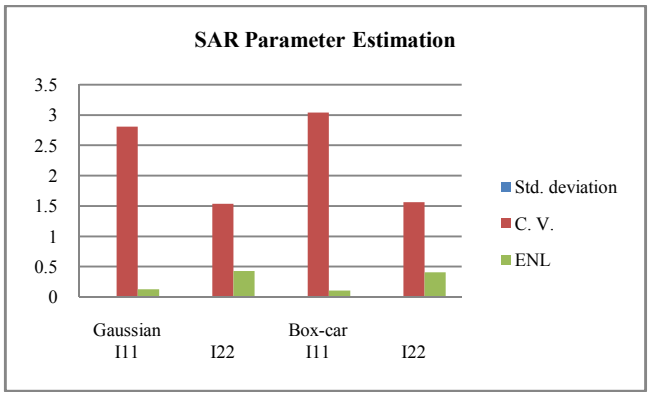


Figure 4 Graph for SAR statistical parameter of Gaussian filter and Box-car filter for TerraSAR-X dataset of Sanchagang, ChinaSAR image.

CONCLUSION

In this paper comparison between Gaussian filter and Box-car filter to remove speckle in multi-look SAR image TerraSAR-X dataset of Sanchagang, China 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 computed and provided comparative simulation model results of both filters using Pol-SAR-Pro Ver. 5.0 and NEST Ver. 5.0.16software.In figure1 (a) and (b)show the I11 for HH polarization and I22 for VV polarization of TerraSAR-X input data image and figure 2 (c), (d) &figure 3 (e), (f) shows the result of Gaussian and Box-car filtered image resp. of I11 for HH polarization & I22 for VV polarization. In Ideal case 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, low Std. deviation(0.0008) of Gaussian filter I22 in figure 2 (d), lower Coefficient Variance(1.5337) of Gaussian filter I22 in figure 2 (d) and higher value ENL(0.4251) of Gaussian filter I22 in same figure 2 (d) image, then conclude that the Gaussian filter I22 in figure 2(d)means Gaussian filter VV polarization image is better than the Box-car filtered image that is in this dataset Gaussian filter is better than the Box-car filter.

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