Paper presented at the 22nd Asian Conference on Remote Sensing, 5 - 9 November 2001, Singapore.

A Study of Target Identification from Multi-temporal SAR Images

C. T. Wang, K. S. Chen, C. T. Chen, and J. M. Kuo
Center for Space and Remote Sensing Research
Institute of Space Science
National Central University
Chung-Li.
Tel : 03-422-7151 ext 7637 Fax : 03-425-5535
Email : ctwang@csrsr.ncu.edu.tw, dkschen@csrsr.ncu.edu, ctchen@csrsr.ncu.edu.tw
Taiwan,ROC

KEY WORDS: synthetic aperture radar, multi-temporal processing, speckle noise, equivalent number of looks

ABSTRACT: The Synthetic Aperture Radar(SAR) is a coherent microwave sensor that can penetrate clouds and can be operated day or night. SAR images are generated by coherently processing the backscattered signals, so they are highly susceptible to the speckle effect. The speckle noise complicates the image interpretation, reduces the effectiveness of image segmentation, and deteriorates the information extraction performance. In this paper, we present a multi-temporal processing technique to reduce the noise while maintain the spatial resolution. After the multi-looking from a time series of image sets, the sample's mean and variance provide a useful information on the target.

The test site is located at the south of Taiwan nearby Kaohsiung City. A series of ERS2 SAR data sets were acquired and processed on February 5, March 12, April 16, May 21, September 3 and December 12 1998. By properly registering these image sets, it is found that the signals of the target are greatly enhanced against the background. The temporal averaging effects are analyzed by calculating the mean and variance of the images along the time axis. The equivalent number of looks of homogeneous area is increased from 4 looks to 12 looks. It is shown that multi-temporal processing is an effective scheme to reduce the speckle noise and thus to improve the quality of SAR imagery. Unlike the spatial averaging approach, the spatial resolution is not degraded. This is useful for identification of the stationary target on the SAR imagery while keeping track of backscattered signal variations of the target.

1. INTRODUCTION

Most images of the earth are generated by focusing and recording reflected solar radiation, and/or the thermal and microwave emitted radiation from the earth surface. The advances in Synthetic Aperture Radar (SAR) technologies brought about a remote sensing capability of an entirely different kind. This instrument can penetrate cloud and can be operated during day or night, it could provide its own illumination The SAR synthesizes a large antenna by the motion of the radar platform to improve the azimuth resolution.

Unlike passive incoherent sensors, a SAR generates images by coherent processing, The speckle appearing in radar images is a natural phenomenon. It is generated by interference of reflected wavelets from many randomly distributed scatter elements within a resolution cell. The speckle noise complicates the image interpretation, reduces the effectiveness of image segmentation, and deteriorates the information extraction performance. We present a multi-temporal processing technique to reduce the noise while to maintain the spatial resolution. After the multi-looking from a time series of image sets, the mean and variance of sample provide a useful information on the target.

2. STATISTICAL PROPERITIES OF SAR IMAGERY

A common approach to speckle reduction is to average several independent estimates of the image. In SAR practice, this is accomplished by dividing the synthetic aperture length into N segments, each segment is processed independently to form either an intensity or an amplitude SAR image. The N images are summed together to form a N-looks SAR image. The N-looks processing reduces the standard deviation of speckle. However, this is accomplished at the expense of resolution, which deteriorates by a factor of N.(Lee, 1992)

For N-Looks SAR intensity image (I), however, the speckle has a Chi-square distribution with 2N degrees of freedom, described as (1),

$$P(I) = (N^N I^{N-1}/(N-1)!s^{2N})EXP(-NI/s^2) \qquad (I \geq 0) \qquad (1)$$

For N-looks SAR amplitude image (A), however, the speckle has a Chi distribution with 2N degrees of freedom, described as (2),

$$P(A) = (2N^N A^{2N-1}/(N-1)!s^{2N})EXP(-NA^2/s^2) \qquad (A \geq 0) \qquad (2)$$

3. METHODS

Generally, it is difficult to extract features from the spaceborne SAR images due to the highly speckle noise. We present the multi-temporal processing using a series of ERS2 SAR data sets were acquired on February 5, March 12, April 16, May 21, September 3 and December 12 1998. These data were processed to 4 looks amplitude detected products.

By properly registering these image sets, the RMS of error of the tie points are less than 0.5 pixel. The temporal averaging effects are analyzed by calculating the mean and variance of the images along the time axis. It is found that the signals of the target are greatly enhanced against the background. It will helpful for target identification.

4. PRIMARY RESULTS

The ratio of the standard deviation to the mean in the homogeneous areas is a good measure of speckle strength. For the filtered SAR images, this ratio also frequently used to measure the performance of speckle reduction. We use the ratio b as the speckle index (Lee, 1994), described as (3).

$$b = \frac{\sqrt{\mathrm{var}(\hat{x})}}{E[\hat{x}]} \qquad (3)$$

Where $\hat{x}$ is the sample value of the SAR image.

Another commonly used criterion is the equivalent number of looks (ENL). The ENL for intensity SAR images (I) is defined as (4) (Lee, 1994)

$$ENL(I) = \frac{1}{b^2} \qquad (4)$$

The ENL for amplitude SAR images (A) is modified as (5) (Lee, 1994)

$$ENL(A) = \left(\frac{0.522}{b}\right)^2 \qquad (5)$$

Where 0.522 is the theoretical value of b for single look amplitude SAR image. The ENL will be consistent from multi-looks to single look .

The test site is located at the south of Taiwan nearby Kaohsiung City. The size of these images is 256 x 256. The Figure 1 is 4-looks amplitude SAR image. The SAR image of figure 2 is the after multi-temporal processed. Obvious, we could clearly identify the sideway from the multi-temporal averaged image.

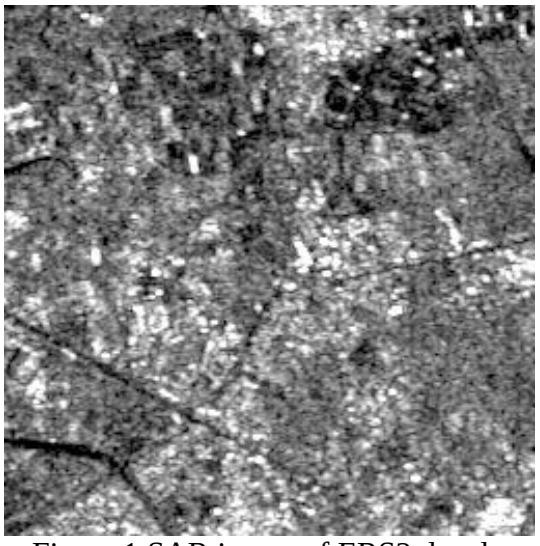

Figure 1 SAR image of ERS2 dated February 5 1998.

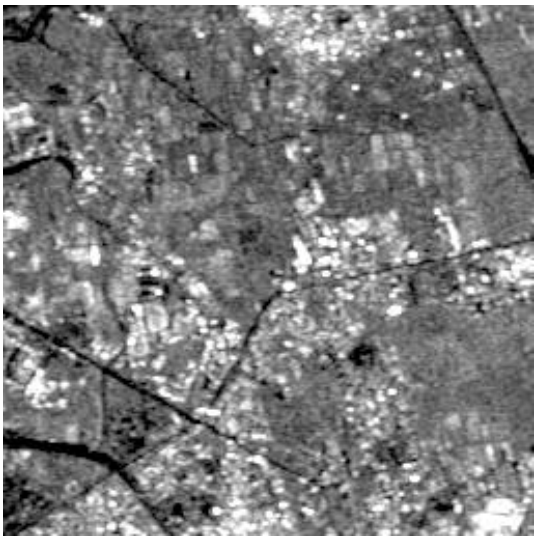

Figure 2 multi-temporal processed image.

We compared the histogram both images on homogeneous area.(see Figure 3 and Figure 4). Both histograms consistent with the curves of distribution function. The ratio of standard deviation to mean was 0.26 for the original SAR image, it reduced to 0.12 after processed. The equivalent number of looks increased from 4 looks to 12 looks. (See Figure 5).

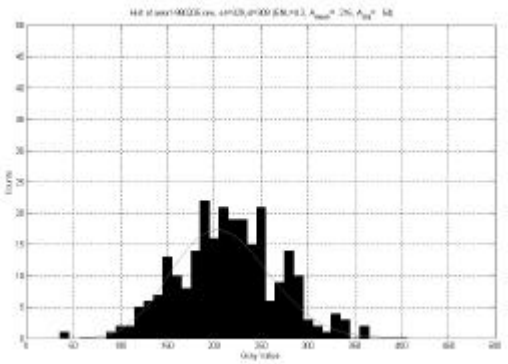

Figure 3 Histogram and curve of distribution of the original image

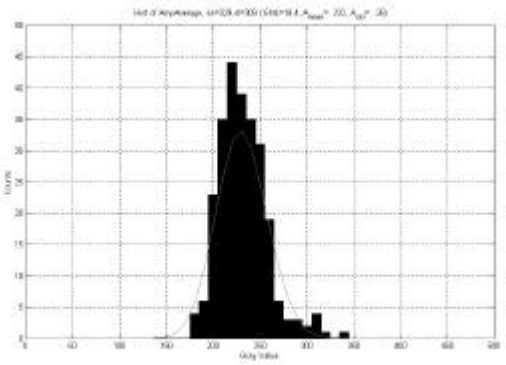

Figure 4 Histogram and curve of distribution of the multi-temporal processed image

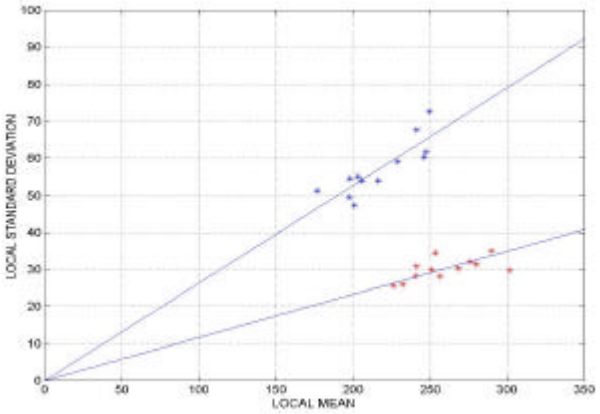

Figure 5 The speckle noise characteristic curves of the original image(blue) and the multi-temporal processed image(red).

The spatial correlation of the multi-temporal processed image is same with the original image.(see Figure 6 and Figure 7) We proved that the procession is reserve the spatial resolution. Unlike the other spatial filters will degrade the spatial resolution.

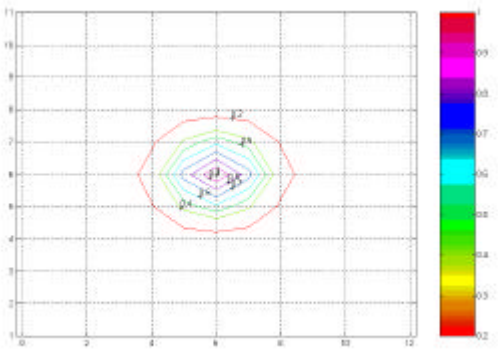

Figure 6 The spatial correlation of original image

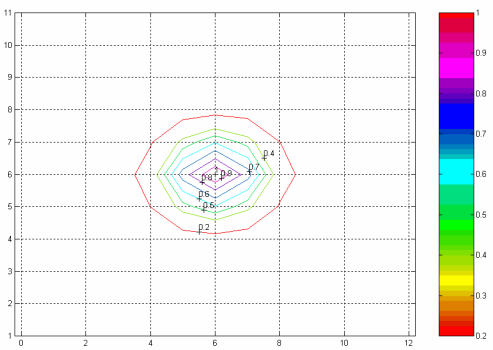

Figure 7 The spatial correlation of multi-temporal processed image

5. Summery

It is found that the signals of the target are greatly enhanced against the background. The temporal averaging effects are analyzed by calculating the mean and variance of the images along the time axis. The equivalent number of looks of homogeneous area is increased from 4 looks to 12 looks.

It is shown that multi-temporal processing is an effective means to reduce the speckle noise and thus to improve the quality of SAR imagery. Unlike the spatial averaging approach, the spatial resolution is not degraded. This is useful for identification of the stationary target on the SAR imagery while keeping track of backscattered signal variations of the target. In further, we should remove the temporal correlation of these multi-looking SAR images to avoid the change of the target.

6. Reference

Lee, Jong-Sen, et al(1992). Unsupervised Estimation of Speckle Noise in Radar Images, Int. Journal of Imaging Systems and Technology, Vol.4, pp 298-305.

Lee, Jong-Sen, et al(1994). Speckle Filtering of Synthetic Aperture Radar Images: A Review, Remote Sensing Reviews, Vol.8, pp 313-340.