SPECKLE FILTERING OF DUAL-POLARIZATION AND POLARIMETRIC SAR DATA BASED ON IMPROVED SIGMA FILTER

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Abstract

The advancement of SAR technology with high resolution and multiple polarization data demands better and efficient speckle filtering algorithms. Recently, several PolSAR and Pol-InSAR speckle filtering algorithm has been developed, notably by Vasil et al. [1] and Lopez-Martinez et al. (IGARSS 2007) for speckle reduction of polarimetric SAR and Pol-InSAR data. In this paper, we developed an effective speckle filtering algorithm that is also computational efficient based on the improved sigma filter. The sigma filter [2] was developed, more than 20 years ago, for a single SAR image based on the simple concept of two sigma probability, and is reasonably effective in speckle filtering. However, deficiencies were discovered in producing biased estimation, in blurring and in depressing strong reflected targets. In this paper, we extend and improve the sigma filter by eliminating these deficiencies. The bias problem is solved by redefining the sigma range based on the speckle probability density functions. To mitigate the problems of blurring and depressing strong reflective scatterers, a target signature preservation technique is developed. This improved sigma filter is then extended to filter the dual-polarization and polarimetric SAR data.

The principals [3, 4] underlined dual-polarization and polarimetric SAR speckle filtering are

1) To preserve the statistical characteristics, each term of the covariance or coherency matrix should be filtered in a manner similar to multi-look processing by averaging the matrix. In other words, all terms of the matrix should be filtered identically.
2) To avoid introducing cross-talk between polarizations, each term should be filtered statistically independent of other terms. Filtering algorithms exploiting the degree of statistical dependence between polarizations will introduce cross-talk.
3) To preserve polarimetric properties, only pixels possessed similar scattering mechanism should be included in the filtering.

When filtering polarimetric SAR data, the first priority is not to destroy the nice statistical structure inherent in SAR data. If we filter each element separately, for example, the correlation between polarizations would be affected producing the bad effect that the correlation coefficient may be greater than the value of 1. Also, following these principals, we will ensure the filtered coherency matrix remains complex Wishart distributed.

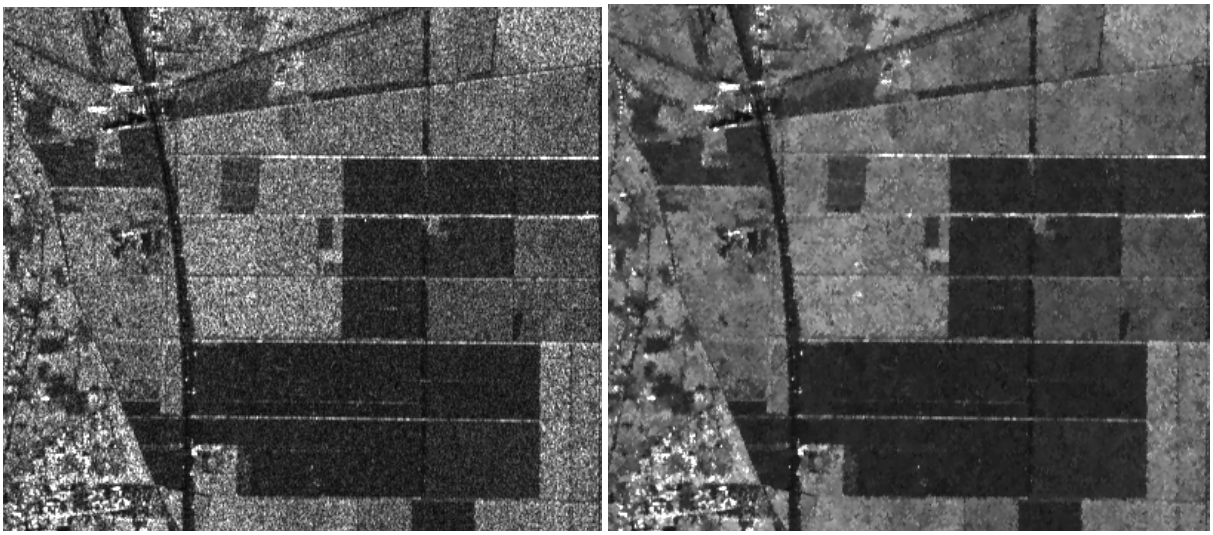
The basic steps of the proposed filtering algorithm are given as follows:

Step 1: Compute the boundaries of a selected sigma range (0.9). The boundary is computed taking into consideration of the asymmetrical distribution of speckle probability density function. This procedure removes the bias problem associated with the sigma filter.

Step 2: In a moving window, select pixels with similar scattering property as the center pixel. For polarimetric SAR data, |HH+VV|, |HH-VV| and 2|HV| are applied to select homogeneous pixels within their established sigma boundaries. Only pixels selected by all three polarizations are included in the filtering. Other pixels are considered as outliers, and will be ignored.

Step 3: Apply minimum mean square filter to the selected pixels. Equal weight should be used for filtering.

The NASA JPL AIRSAR P-band polarimetric SAR data of Les Landes Forest, France is used for illustration. Only the |HH| term is shown here for its effectiveness in speckle filtering (Fig. 1).



(A) Original 4-look |HH| image (B) Speckle filtered |HH| image

Figure 1 Speckle filtering by the improved sigma filter

References:

[1] G. Vasile, E. Trouve, J.S. Lee and V. Buzuloiu, "Intensity-Driven-adaptive-neighborhood Technique for Polarimetric and Interferometric Parameter Estimation," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 44, no. 6, 1609-1621, June 2006.

[2] J.S. Lee, "A Simple Speckle Smoothing Algorithm for Synthetic Aperture Radar Images," *IEEE Trans. on Systems, Man and Cybernetics*, Vol. SMC-13, No. 1, pp.85-89, 1983.

[3] J.S. Lee, D.L. Schuler, M.R. Grunes, E. Pottier, and L. Ferro-Famil, "Scattering Model Based Speckle Filtering of Polarimetric SAR Data," *IEEE Transactions on Geoscience and Remote Sensing*, vol.44, No. 1, 176-187, January 2006.

[4] J.S. Lee, M.R. Grunes and G. De Grandi, "Polarimetric SAR Speckle Filtering and Its Impact on Terrain Classification" *IEEE Transactions on Geoscience and Remote Sensing*, vol. 37, no. 5, 2363-2373, September 1999.