Filtering and Segmentation of radar imagery

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Abstract

The purpose of this study is to demonstrate a variety of methods for reducing the speckle noise content of SAR images, whilst at the same time retaining the fined details and average radiometric properties of the original data.

In order to increase the accuracy of classification, Two categories of filters are used (speckleblind(simple), Speckle aware(intelligent)) and Segmentation of highly speckled radar imagery is achieved by the use of the Gaussian Markov Random Field model(GMRF).

The problems in applying filtering techniques to different object types are discussed and the GMRF procedure and efficiency of the segmentation also discussed.

1. Introduction

In recent years, Synthetic aperture radar (SAR) imaging has been rapidly gaining prominence in applications because it has ability to image the Earth's surface in nearly all weather conditions, together with high spatial resolution. One of the most obvious differences between images acquired by optical sensors and those acquired by Synthetic Aperture Radar is the very high noise content (speckle) of the latter which serves to obscure fine details in the images and to also make SAR images unsuitable for classification using conventional pixel classifiers (e.g. Maximum Likelihood). Understandably therefore a great deal of attention has been paid to methods of removing, or at least minimizing, the noise content of SAR images, without yielding a detrimental effect on their information content.

Excellent work has been done on classifications using SAR images for both natureal and built targets(Van Zyl 1989, Freeman and Durden 1992, Touzi et al. 1992, Pierce et al. 1994, Dobson et al. 1995, 1996, Nezry et al. 1996, Dong et al. 1996, Luckman et al. 1997). In order to increase the accuracy of classification, Pierce et al. (1994) used information averaged from multi-pixels(2 x 2 pixels, for example), wheres Dobson et al. (1996)) performed segmentation before classification.

Segmentation segments an image into disjoined regions corresponding to objects, or parts of objects that differ from their surroundings, and thus enables further classification to be performed based on the information provided by clusters rather than individual pixels. The procedure of segmentation is, therefore, fundamental for many tasks of image processing and classification (Y. Dong, B. C. Forester 1999)

2. Data and Methodology

2.1 Sampling

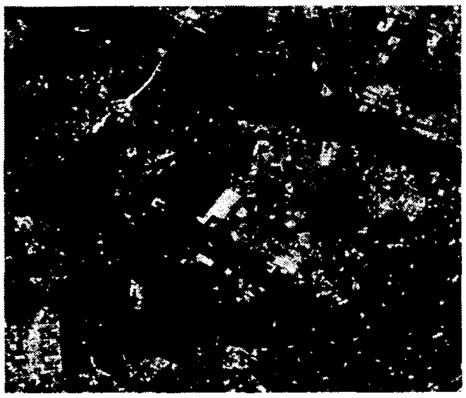

Fig. 1.Main study area (LandsatTM)

Fig 2. Interpolated SAR image

The daunting amount of acquired data can not be handled at the same time and also selecting the appropriate filter for the different type of objects is not easy. So we consider three methods: one is simply decide the train area such as urban area, agriculture, and Mountain and another is resize the image using the bilinear interpolation or simply select every 2 or 3 pixel and the other is quadtree method. RADARSAT radar imagery and Landsat TM was used for this study

The linear interpolation function defined as:

$$rho = \frac{\sum_{i=0}^{N-1}(Rx_i - \overline{Rx})(Ry_i - \overline{Ry})}{\sqrt{\sum_{i=0}^{N-1}(Rx_i - \overline{Rx})^2}\sqrt{\sum_{i=0}^{N-1}(Ry_i - \overline{Ry})^2}}$$

To specifiy a particular level in the quadtree, we use a positive integer l as a subscript. The lowest level will be assigned the value l =1: subsequently higher levels will be assigned the correspondingly larger integral values. Using this labeling , we will then denote the lth level of the quadtree Y, Y and nodes within that level as Y [m,n] and coarser levels with a dyadically decreasing resolution are obtained using following recursion:

$$Y_l[m,n] = \sum_{i=2m-1}^{2m} \sum_{j=2n-1}^{2n} Y_{l-1}[i,j]$$

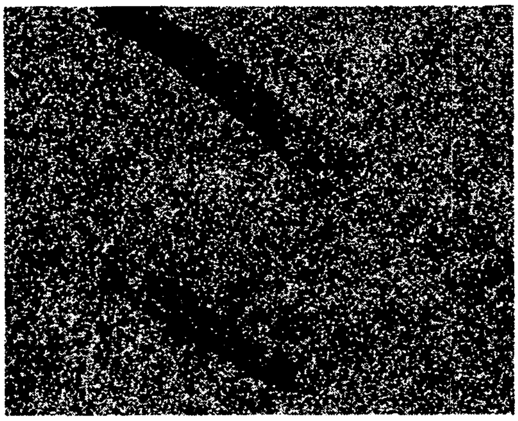

Fig. 3. 3 level of the quadtree image

2.2 Filtering

Filtering of SAR images to remove speckle has long been a subject of interest and each year a number of new filters (usually refinements of existing ones) are published in the literature. We divided the Filters into two categories.

Speckle "blind" (simple)

a. Mean b. Median c. EPS (Edge Preserving Smoothing)

Speckle "aware" (intelligent)

a. Lee b. Frost

c. Weighted sigma d. Kuan e. Gamma

Different window size and the number of times (iterrations) a filter is run on an image

Statistics recorded for Regions of Interest(ROI) after each pass (iteration) of the filter for each filter window size.

2.3 Segmentation

When an area illuminated by a radar contains many elementary scatters which are randomly distributed in terms of size, orientation and location, the backscattering measurements for the area have an approximate Gaussian distribution(Rignot and Chellappa 1992, Lee et al. 1994) If we are interested in the intensity measurements the conditional probability density function of the measurement vector x given a region S is (Goodman 1985) (Y. Dong, B. C. Forester 1999).

$$p(X|S)=\frac{1}{(2\pi)^{n/2}|C_0|^{1/2}}\exp\{-\frac{1}{2}(X-\overline{X})^T C_0^{-1}(X-\overline{X})\},$$

The GMRF model considers two regions to be different if one or more than one of the following conditions is true

1. The first order statistics(the means for a single-channel image) are different
2. The second order statistics(the variances for a single-channel image) are different
3. The spatial textures are different

Under the above condition, In general there are three steps:

A. Filtering,

The filters which mentioned above are tested whether the traditional speckle suppression methods are efficient or not

B. Initial segmentation,

Initial segmentation is essential to the GMRF method since the model parameter estimation requires segment statistics. A large number of initial leads to an enormous computing burden for segment merging, as the algorithm for segment merging requires significant calculations. to overcome these problems, techniques of wavelet transform (Dong, et al. 1997, 1998) (Y. Dong, B. C. Forester 1999) is used for the initial segmentation

C. segment merging.

The criterion used for the segment merging is similar to an approach used by panjwani and Healey (1995) and silverman and cooper (1988), Y. Dong, B. C. Forester(1999).

3 Results and Discussion

3.3 Sampling Method

The big image filtering is heavy burden and also large number of initial segments leads to an enormous computing burden for segment merging So that sampling or selecting the study area is very useful. The bilinear interpolation method is very useful in applying the various filters to find out which filter efficiently reduce the speckle but the quadtree method is only good at partial analysis.

3.4 Filtering

The median filtering is effective in removing "salt and pepper" noise, (isolated high or low values). The scalar median is simply the middle value, which should not be confused with the average value (e.g., the median of the array [1,10,4] is 4, while the average is 5.). The two categories(blind, intelligent) are separated based on that the latter type taking into account of speckle model (how speckle occur in SAR image) so that the last type is much better comparing to the first type which is only blind applying.

3.5 Segmentation

Segmentation of RADARSAT imagery (512 x 512) has been conducted using the GMRF Model. Techniques of wavelet transforms are used to obtain initial segmentation. This testing conducted only on single-channel image. The selection of appropriate neighbourhood sets is an important aspect of designing random field models. Fig. 4. Shows the parameter estimated image.

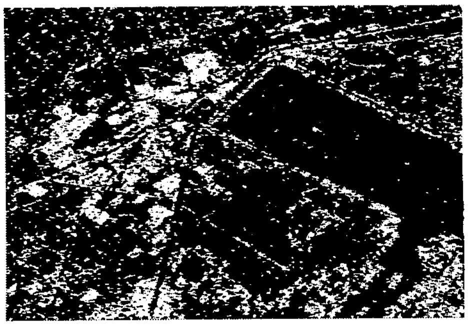

Fig. 4. Parameter estimated image

4 Conclusion

Among the applied filters, Lee filter 5x5 , 3 passes good for agriculture area and the intelligent filters are better than blind filters in speckle reduction. When the window size became lager and iteration repeated, the image became blur. . The segmentation of RADARSAT imagery successfully segmented in spite of speckle.

5. Acknowledgment

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References

BOUMAN, C., AND LIU, B., 1991, Multiple resolution segmentation of textured images. IEEE Transactions on Pattern Analysis and Machine Intelligenc, 13, 99-113

CHELLAPPA, R., CHATTERJEE, S. S., and BAGDAZIAN, R., 1985, Texture synthesis and compression using Gaussian-Markov random field models. IEEE Transactions on Systems, man and Cybernetics, 15, 298-303.

DOBSON, M. C., PIERCE, L. E., AND Ulaby, f.t., 1996, Knowledge-based land-cover classification using ERS-1/JERS-1 SAR composites. IEEE Transactions on Geosicence and Remote Sensing, 34, 83-99

DONG, Y., FORSTER, B. C., MILINE, A. K., and MORGAN, G. A., 1998, Speckle suppression using wavelet transforms. IJRS, 19, 317-330

DONG, Y., FORSTER, B. C., MILINE, A. K., and MORGAN, G. A., 1999, Segmentation of radar imagery. IJRS, Vol. 20, 1617-1639