UNSUPERVISED CLASSIFICATION OF POLARIMETRIC SAR DATA USING IMAGE CLUSTERING AND H/A/α DECOMPOSITION

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ABSTRACT:

This paper proposed a method of unsupervised classification of polarimetric SAR data based on image clustering and H/A/α decomposition. Fully polarimetric L band data collected by ALOS PALSAR system was used in this paper. The study site locates in Tianjin, China. The area is characterized by rural residence, bare soil, water body and pond. An unsupervised classification method is proposed for fully polarimetric SAR data. The relation between physical structure and polarimetric signal properties is studied explicitly using polarimetric decomposition. Consequently, a method based on clustering and iteration was introduced and was shown to yield radar-derived maps with a high level of agreement with existing TM images.

1. INTRODUCTION

For centuries, maps have provided important information in various fields. People's need for maps of high accuracy never decreased. Especially when a nature catastrophe occurs, there is a great demand for obtaining maps about disaster information fast and accurately. The reliability of maps derived from remotely sensed data depends upon an accurate classification. This paper proposed an improved method of semiautomatic classification of polarimetric data using the data clustering function in the software POLSARPRO provided by ESA. What is valuable is that the effort contributes a lot in improving both the speed and the accuracy of classification of SAR images.

Spectral noise is a disturbing factor affecting the recognition of target and thus become a key problem in SAR data classification. Although there are many kinds of filter available, the effect is not very satisfying. The classical H, A, α could neither not solve the problem very well. Fortunately, the function of data clustering in POLSARPRO is a good approach for the obstacle. Based on the classical H/A/α plane, we used data clustering during the classification and we got an encouraging result.

2. DATA

The study area is in Tianjin, China. It ranges from E 117º34' to E 117º45' in longitude, and from N 39º17' to N 39º30' in latitude. The topography is relatively flat. The main land cover types are bare soil, farmland, water body, marsh, salt pond and rural residence. ALOS PALSAR polarimetric data on 2 July 2007 was used in the study. The data has four polarization channels: HH, HV, VH and VV. A Landsat ETM+ image of 122 / 033 (path/row) acquired on 24 July 2007 was used to assist the interpretation procedure.
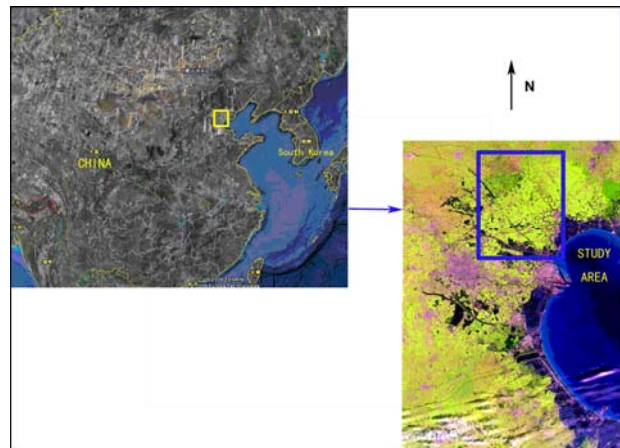

Figure 1. Location of the study area

3. METHODS

3.1 The ''H/A/α'' Polarimetric Decomposition

The ''H/A/α'' decomposition theorem is the basis for the design of the proposed processing scheme for polarimetric SAR images. H, A, α can be obtained from the coherency matrix T:

$$T_3 = \frac{1}{2}\begin{bmatrix} |Shh+Svv|^2 & (Shh+Svv)(Shh-Svv)* & 2(Shh+Svv)Shv* \\ (Shh-Svv)(Shh+Svv)* & |Shh-Svv|^2 & 2(Shh-Svv)Shv* \\ 2Shv(Shh+Svv)* & 2Shv(Shh-Svv)* & 4|Shv|^2 \end{bmatrix} \quad (1)$$

The entropy, H, indicates the degree of statistical disorder of the scattering phenomenon. The anisotropy, A, is defined as the relative importance of the secondary scattering mechanisms and the angle α indicates the nature of the dominant scattering mechanism. The whole image is decomposed into segments

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using unsupervised statistical procedures. Each cluster is a group of connected pixels with a similar polarimetric behaviour (Laurent Ferro-Famil, Eric Pottier.2001). Figure 2 shows the flow of the segmentation.
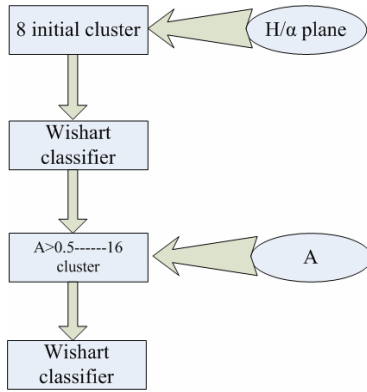

Figure 2. H/A/α classifier

3.2 The Freeman Decomposition

The Freeman decomposition models the covariance matrix as the contribution of three scattering mechanisms:

• Fv: Volume scattering where a canopy scatterer is modeled as a set of randomly oriented dipoles.

• Fd: Double-bounce scattering modeled by a dihedral corner reflector.

• Fs: Surface or single-bounce scattering modeled by a first-order Bragg surface scatterer (http://earth.esa.int/polsarpro).

Where

$$Fv = \begin{cases} |Shh|^2 + 2|Shv|^2 + |Svv|^2 = span \\ 8|Shv|^2 \quad (|Shh|^2 < 3|Shv|^2) \\ 8|Shv|^2 \quad (|Svv|^2 < 3|Shv|^2) \end{cases} \quad (2)$$

In this paper, we use Fv as a complement to further refinement of the classification due to its ability to reflect the mechanism of targets. High value of Fv suggests strong volume scattering and lower value of Fv often indicates strong surface scattering.

Figure 3 shows the four parameters that we employed during the classification.

(a) Entropy H (b) Anisotropy A
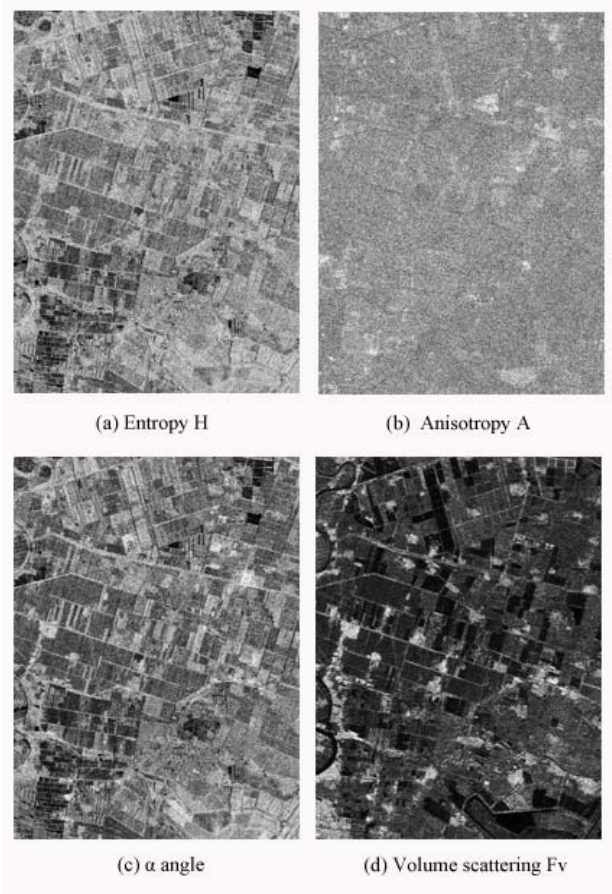
(c) α angle (d) Volume scattering Fv

Figure 3. Parameters H, A, α, Fv

3.3 Fv's Contribution

Fv represents volume scattering power information about targets. It indicates targets' scattering mechanism. Targets like forest and buildings often have a high value of Fv. On the contrary, water body and flat ground may have a lower value of Fv due to the specular reflection. We assumed that the value of Fv would be very close for targets behaving similarly. For this reason, we first located regions in the Wishart H/A/α segmentation result class by class. Then we found the regions we need to deal with by calculating the pixels the region contained. In this paper, we make a clustering process on regions that contain less than 20 pixels. We calculate the mean value of Fv of these regions and we define it as Fv_0. Third, we found the surrounding areas of these regions. We also calculated the mean value of Fv of these neighbouring regions, and we define these mean values as Fv_1, Fv_2, Fv_3…. In the meanwhile, we define distance $\Delta d = Fv_i - Fv_0$. Finally, we look for the minimum distance neighbouring cluster and we merged it with the target regions. Below we show an example of the procedure in Figure 4 and 5. The blue one in Fig 4 is the target region that contains less than 20 pixels. There are five regions around it. We calculate the mean Fv value of each region and the distance of the value between the neighbouring region and the target region (Δd). Finally, we merge the region that with the minimal Δd (the yellow one is the region with minimal Δd) with the target region.
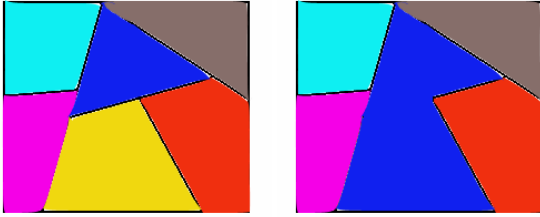
Figure 4. Original image   Figure 5. Image after clustering

3.4 Processing Flow

The Volume scattering Fv derived from the Freeman decomposition combined with the entropy H, the α angle and the anisotropy A were used as discriminates in the polarimetric SAR data processing. Fv has additional information that is not contained in the H/A/α, and this information is key to the classification. Below is the data processing flow.

(1) Extract the coherent matrix [T3] from SAR data;
(2) Employ Cloude-Pottier decomposition to get H, A, α;
(3) Employ Freeman decomposition to get Fv;
(4) Employ the H/A/α methods to realize an unsupervised Wishart H/A/α segmentation procedure;
(5) Data clustering using Fv and the result of the previous Wishart H-A-α segmentation.
(6) Iterate till we get the satisfied result.
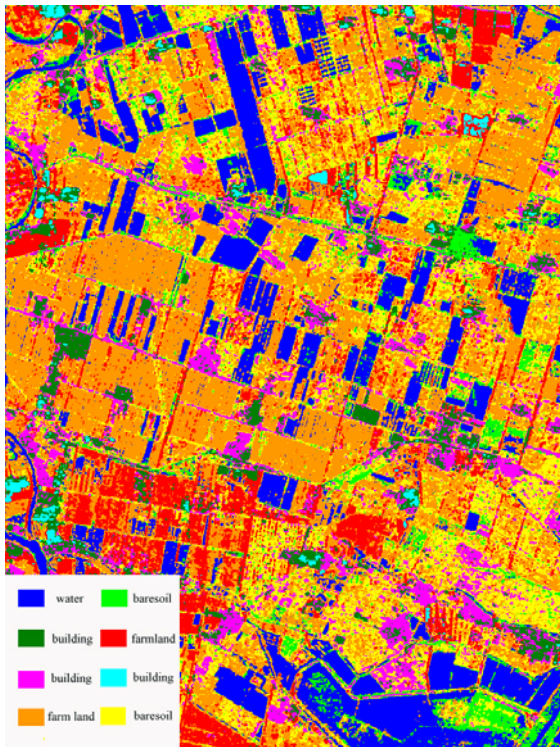
4. RESULTS

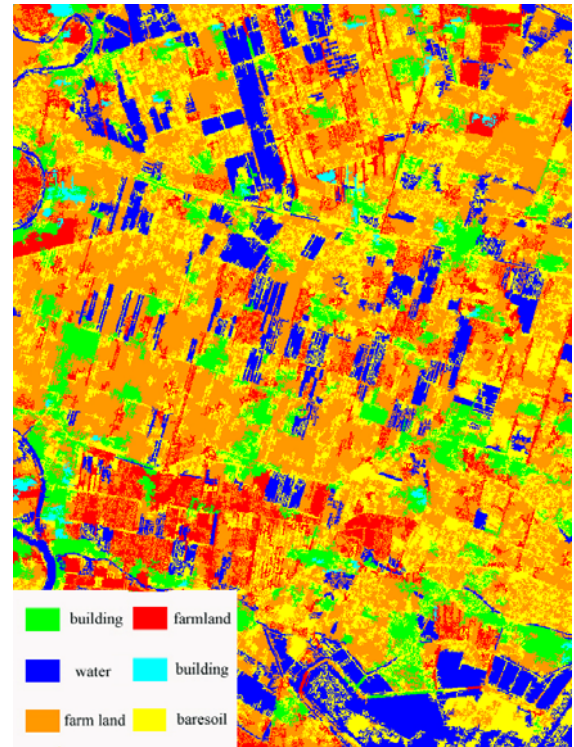
Figure 6. Wishart unsupervised classification

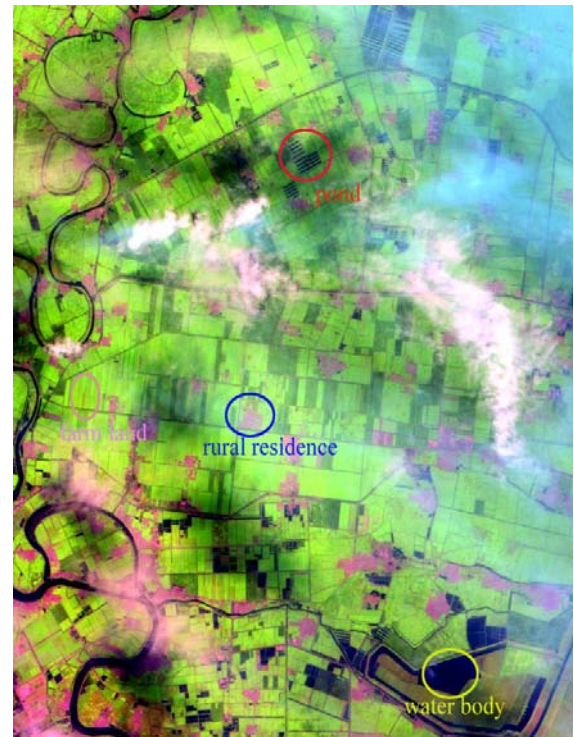Figure 7. Classification using data clustering

Figure 8. the Corresponding TM data

From Figure 7 we can easily see that rural residence (in green) was more precisely classified compared to the Wishart unsupervised classification. Rural residences in Figure 6 were classified into 2 classes (in pink and in dark green) while in Figure 7 they were not. And in the lower right part of the two pictures, we can see that marsh was better distinguished using the method this paper proposed. From Figure 8, we can see that

the classification of rural residences (in green in Figure 7), water body and pond (in blue in Figure 7) have a high level of coherency with the TM image.

Furthermore, the data clustering function also performed a prominent function in eliminating the noise effect in radar images and thus is considered to be a qualifying solution during the image classification. The noise effect was tremendously reduced after data clustering.

Finally, it saves a lot of time and it is shown that the proposed classification method provides better performance than the general Wishart H/A/α classification.

5. CONCLUSIONS

The 'H/A/α' decomposition theorem is the basis for the design of the proposed processing scheme for polarimetric SAR images. An improved land-cover classification based on this indicates the scattering properties of target classes very well and hence can be used to produce a much more improved classification result. The volume scattering Fv from the Freeman decomposition contributes a significant part to the improvement of classification.

The data clustering function in the POLSARPRO is also an effective scheme for the noise reduction in the radar images. In order to make full use of the full polarimetric radar image, several iterations clustering is suggested.

REFERENCES

References from Journals:
R.Touzi, R. Landry, and F.J. Charbonneau., 2004. Forest type discrimination using calibrated C-band polarimetric SAR data. Can. J. Remote Sensing, 30(3), pp. 543–551.

T. Macrì` Pellizzeri., 2003., Classification of polarimetric SAR images of suburban areas using joint annealed segmentation and ''H/A/a'' polarimetric decomposition. ISPRS Journal of Photogrammetry & Remote Sensing, 58, pp. 55– 70.

References from Other Literature:
Dirk H. Hoekman and Marcela J.Quiñones., 2001. Biophysical Forest Type Characterisation in the Colombian Amazon by Airborne Polarimetric SAR. In: IEEE Transactions on Geoscience and Remote Sensing, pp.1406-1408.

Laurent Ferro-Famil and E. Pottier, J.S. Lee.,2001. Unsupervised Classification of Multifrequency and Fully Polarimetric SAR Images Based on the H/A/Alpha-Wishart Classifier. In: IEEE Transactions on Geoscience and Remote Sensing, 39, pp. 2332-2342.

M. Mahmudur Rahman and Josaphat Tetuko Sri Sumantyo., 2008. ALOS PALSAR DATA FOR TROPICAL FOREST INTERPRETATION AND MAPPING. In: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVII, Part B7.

Shane Robert Cloude and Eric Pottier., 1997. An Entropy Based Classification Scheme for Land Applications of Polarimetric SAR. In: IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL.35, NO.1.

References from websites:
http://earth.esa.int/polsarpro