A NOVEL EDGE-DETECTION BASED SEGMENTATION ALGORITHM FOR POLARIMETRIC SAR IMAGES

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ABSTRACT:

Aiming at overcoming the disadvantages of the algorithm proposed by White, R. G. (RGW) and making it applicable for PolSAR data classification, a novel edge-detection algorithm based on segmentation for Polarimetric SAR images is proposed in this paper. As one of the famous algorithms based on objected-oriented segmentation, RGW has been used extensively in image segmentation. However, it also has some disadvantages such as a large number of small regions in the segmentation result. In this paper, after a series of pre-processing including edge enhancement and edge detection, the initial segmented small regions are merged according to the region distance defined by distance of coherence matrix of PolSAR data, and discrete points (at the position of edges) are merged into regions according to Wishart distance. We applied the new algorithm to NASA/JPL AIRSAR L band data of Flevoland, Netherlands. Compared with RGW, experiment results demonstrate that the region of Flevoland resulting from our method get superior segment results. In addition, a better classification result is derived from the segmentation result. What's more, the method has the advantage of edge holding while implementing classification.

1. INTRODUCTION

1.1 General Instructions

Most recent classification works have concentrated on point-based classification of SAR data. These methods are mainly based on spectral characteristic of pixels. But there may be some problems with those methods when applied to high resolution images, e.g. there are discrete points existing in the results and edges between regions are not clear. Also these methods are only lower level understanding of images, since consideration of single pixel characteristic in isolation neglects the rich and complex information of land covers. In such cases, misclassification often happens; also the result may contain a significant amount of salt-pepper noise. Thus, object-oriented classifications are proposed. Image segmentation is the precondition and foundation of object-oriented classification of high resolution remotely sensed images and the quality of image segmentation greatly influences/affects the accuracy of the following processing.

But efficient segmentation algorithms for high resolution remotely sensed images are rarely seen, especially for PolSAR data. RGW algorithm presented by White [1] [2] aiming at processing common remote sensing images is an edge-detection based segmentation algorithm which exploits the cartoon model and includes adaptive filter size. But, the RGW segmentation results may often contain a large number of small regions, in which some segments result from the choice of threshold, and some ones are probably anomalies arising from flaws in the algorithm [3] [4].

In order to overcome the disadvantages of RGW method mentioned above, and make it applicable for PolSAR data classification, one novel segmentation algorithm based on edge-detection is proposed in this paper.

The algorithm is applied to NASA/JPL AIRSAR L band data of Flevoland, Netherlands to test the validity. Classification results based on the segmentation result using our algorithm demonstrate that the region of Flevoland is well classified and the edges are well preserved.

1.2 Paper Structure

This paper is organized as follows: Section II presents methodology consisting of (a) pre-processing of PolSAR data, (b) introduction of edge-detection method used in the algorithm proposed in this paper, (c) introduction of region-growing in the algorithm, (d) features and improvements of the algorithm proposed in this paper. Section III, presents the experiment the proposed method using AIRSAR data, and gives classification results derived from the experiment. This part also gives brief evaluation of the algorithm and the experiment results. Section IV is the conclusion.

2. METHODOLOGY

First of all a pre-processing should be done to the PolSAR data, including decompression, coherence matrix computation and

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Cloude decomposition to calculate the parameters which would be used in the following steps. Then the implementation flow of the algorithm proposed in this paper is introduced. Before the segmentation the edges within the image are detected initially. Then regions are grown between these edges. So the edge detection is crucial to the following steps.

2.1 Pre-Processing of PolSAR Data

First of all the Cloude decomposition is implemented to compute the parameter H (scatting entropy) and alpha (scatting angle) according to PolSAR data.

Usually the PolSAR image is stored in the form of compressed Stokes matrixes (or Muller matrixes) M. Before implementing the algorithm mentioned in this paper, it is necessary to convert Stokes matrixes M to coherence matrixes T. Firstly, the raw data is decompressed into matrix M. Details of decompressing steps can refer to the relevant papers [5]. The computation of coherence matrix form M and Cloude decomposition of coherence matrix please browse the related articles [6][7] for detailed information.

2.2 Introduction of Edge Detection

The edge-detection stage in this process as follows.

2.2.1 Pre-Processing: Pre-processing is implemented to eliminate the influence of speckles. Here a 3 by 3 averaging filter is applied to each channel of coherence metrics respectively.

2.2.2 Edge Enhancing Templates Construction: 3×7 and 7×3 windows as edge enhancing templates are constructed around each pixel to enhance horizontal and vertical edge information. Edge enhancing templates as follows:

-1	-1	-1	0	1	1	1
-1	-1	-1	0	1	1	1
-1	-1	-1	0	1	1	1

Table 1. 3 by 7 Template

-1	-1	-1
-1	-1	-1
-1	-1	-1
0	0	0
1	1	1
1	1	1
1	1	1

Table 2. 7 by 3 Template

2.2.3 Edge Enhancement: The edge enhancing templates constructed above is applied to H and alpha parameter images.

2.2.4 Edge Detection: Then canny edge detector is implemented. First, we use canny edge detector to process the two parameter images respectively. Then the derived edges are added to derive the final edge detection results.

2.3 Introduction of Region Growing

The region-growing stage of the algorithm processed as follows.

2.3.1 Initialization: A series of structure elements are laid on the image so as not to contain any detected edges [3].

2.3.2 Region & Region Merge: Only small regions and adjacent regions are merged to form larger regions according to distance between coherences matrices of two regions. The distance between coherences matrices of two regions are defined as below:

$$d_{rr}\left(\overline{T}_1,\overline{T}_2\right)=\frac{1}{n}\sum_j\sum_i\left(\left|t_1^{ij}-t_2^{ij}\right|\right) \quad (1)$$

Where t_1^{ij} is element of $\overline{T}_1$ at the position of (i, j). $\overline{T}_1,\overline{T}_2$ are the centers coherence matrices of the two regions respectively.

The center coherence matrix can be calculated as below:

$$\overline{T}=\frac{1}{N}\sum_{i=1}^{N}T_i \quad (2)$$

Where T_i is the coherence of i-th pixel of the region. N is the total number of pixels of the region.

2.3.3 Discrete Points to Region Merge: Discrete Points (at the position of edges) are merged into regions according to point–to–region distance. Each point would be merged into region with the shortest point–to–region distance. Here we use Wishart distance [8], which often used by PolSAR classification, as the point–to–region distance:

$$d_{pr}\left(T,X_m\right)=\ln\left|\overline{T}_m\right|+tr\left(\overline{T}_m^{-1}T\right) \quad (3)$$

Where $tr\left(\overline{T}_m^{-1}T\right)$ is the trace of $\overline{T}_m^{-1}T$ matrix.

$\overline{T}_m$ is the center coherence matrix of the m-th region.

2.4 Algorithm Features and Improvements

Some important features and improvements of this algorithm proposed in this paper are as follows:

2.4.1 Applicability for PolSAR Data: Here, the algorithm is applicable for PolSAR data segmentation and classification. The edge-detection-based segmentation algorithms are seldom used for PolSAR data, while PolSAR data can provide more information than traditional SAR data. It is considered that the parameters, H and alpha, derived from the target decomposition of the PolSAR data, have better discrimination for objects []. So the information of those two channels is more credible for feature extraction than that of other channels, e.g. VV, HH, HV etc. The experiment results in this paper give supports for this point.

2.4.2 Edge Enhancement Template: Here 3×7 and 7×3 windows are proposed as edge enhancing templates to enhance horizontal and vertical edge information.

2.4.3 Canny Edge Detector: Canny edge detector is performed after a series of pre-processing procedures, such as edge enhancement.

2.4.4 Region Merging: Large regions won't be merged into others in the following region merging steps while small ones can be merged into any other one.

Large regions won't merge with each other in order to avoid the combination of heterogeneous regions across the undetected edges which really exist., In condition that two large regions are not merged into each other even though they satisfy the criterion for merging, this won't effect the following processing, such as classification, enhancement and so on . As we know, the large regions contain enough pixels to represent the statistical characteristic of the region, which can avoid the influence of the speckles.

Small regions can merge with each other or into large ones, where two cases are considered. If the pixel numbers in the small region is less than a threshold, it will be directly merged into the nearest region. Otherwise, the similarity between this region with the nearest one is considered, one threshold is set to decide whether it involves into merging. The minimum size is set to be 3×3 to ensure the segmentation accuracy of boundary regions.

2.4.5 Point-to-region merge: Point-to-region merging is to realize the segmentation of the whole image. Some regions smaller than 3×3 and boundary pixels are left after region merging, which are called discrete points. In order to realize the thorough segmentation of the whole image, those discrete points should be merged into corresponding regions. In this step, Wishart distance of point-to-region or point-to-class is used as the criterion for merging or discrimination.

3. EXPERIMENTS AND RESULTS

3.1 Experiment Data Introduction

Experiment data is L band full polarimetric image acquired over the Flevoland area by JPL AIRSAR, 1989. The Flevoland site is in a polder of 30 by 60 km located in the center of the Netherlands. The topography is almost perfectly flat. The landscape is quite simple. It mainly shows agricultural fields, forest areas, and only a few urban areas. The forest areas consist of young deciduous trees planted in a regular row pattern. The agricultural fields are cultivated by private as well as state farms. Figure 1 shows intensity image of VV polarization synthesization of the region, Flevoland.

Figure 1. Intensity image of VV of the region, Flevoland

3.2 Experiments

Segmentation of the experiment data is performed using the algorithm proposed in this paper. Figure 2 shows the segmentation result, in which each region is given the mean value of H. In order to verify the validity of the segmentation result, a simple classification using the segment results [8] is performed and the result is compared with that got using point based classification method. The results are shown in Figure 3 and Figure 4.

From the analysis of results we can conclude four points bellow:

First: There are no discrete points and seldom small regions in the segmentation results.

Second: Boundaries are very clear, which can be seen from the segmentation results.

Third: The algorithm, at the step of edge detection, has high efficiency and the time complexity is lower than that of RGW.

Fourth: From the simple classification result image we can see that the segmentation algorithm performs very well, and the result is better than that of the point-based classification.

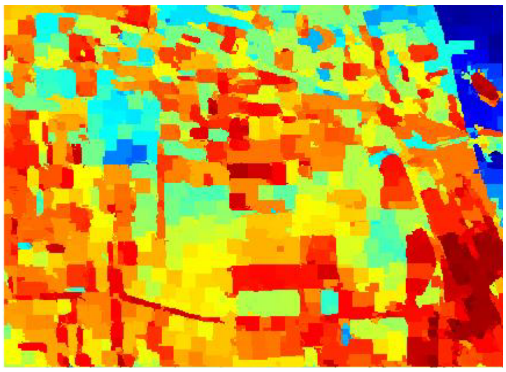

Figure 2. Segmentation result

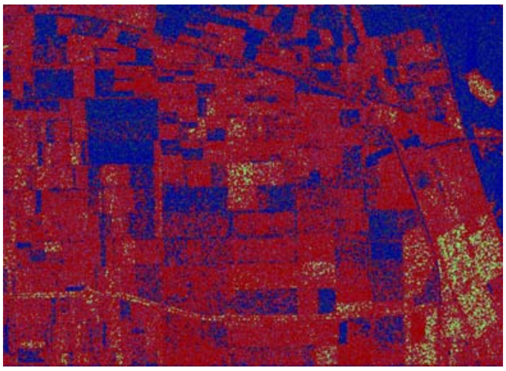

Figure 3. Point-based classification result

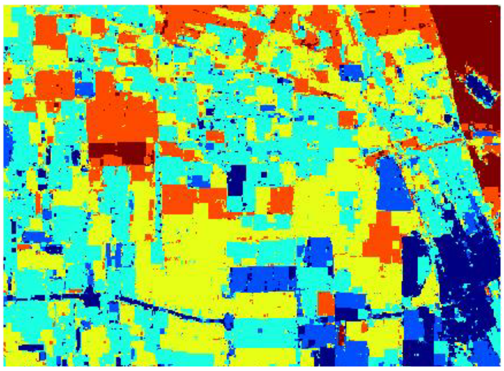

Figure 4. Classification result using segmentation result

4. CONCLUSION

In order to overcome the disadvantages of RGW method, and make it applicable to PolSAR data classification, one novel edge-detection algorithm based segmentation is proposed in this paper. In this paper a new object-oriented classification algorithm is proposed and the features and improvements of the new method are concluded. Also the algorithm to segment is applied AIRSAR PolSAR data. In order to verify the validity of the segmentation result, a simple classification based on the segment results was performed and the result was compared with that got using point based classification method, and the superior classification results got by new method demonstrated the effectiveness of the new segment method.

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