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SEGMENTATION OF SAR IMAGES

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Abstract: This paper presents a new and simple filter useful for the segmentation of SAR (Synthetic Aperture Radar) picture. This filter corresponds to an adiabatic transformation, it is reversible and does not produce information lose. The purpose of the filter is to transform the noise model of the image from multiplicative gaussian to an additive gaussian one which is easier to process.

Résumé: Cet article présente une approche nouvelle et simple pour la segmentation des images SAR(Synthetic Aperture Radar) . Ce filtre peut être considérer comme adiabatique car il est réversible et ne cause aucune perte d'infomation. Le but de ce filtre est de transformer le modèle multiplicatif du bruit de l'image vers un modèle additif qui est plus facile à traiter.

1)Introduction

SAR pictures are generally of lower quality than optical ones. They are corrupted by signal dependant noise, which greatly complicate the interpretation. Most sensers can produce only a limited number of spectral bands etc...

However, many papers try to take advantage of SAR image[1,2,6]. Hence the wave length is in the order of ten centimeters, this means that any smaller object is almost transparent. This includes, of course, clouds and water drops in the atmosphere. Furthermore, radar light source has, in average, a much longer wave length than the sun .Thus, the taken image is not affected (in first approximation) by the sun . The produced image, therefore, is almost independent of the weather condition and depends mostly of the ground state.

Many technics are proposed for the pre-processing of SAR images, for example, the convolution with a median filter which implicitly assumes an additive noise, and the Adaptive Digital Filtering of Frost [1] which minimises the quadratic error. In the proposed approach, this minimisation is done at the segmentation step.

We use the H.S.O(Hierarchical Stepwise Optimization) algorithm [4,5] which produces good result in the segmentation of aerial picture . However ,the advantage of this method is demonstrated for image with a uniform and moderate noise level [5].

This paper proposes a pre-processing of the SAR images which makes the noise uniform over the all image. The noise on SAR image can be approximate by a gaussian multiplicative model[6,7]. This paper presents a filter which change the image into a more optical like model.

2)The Adiabatic Filter

The HSO algorithm had already proved to be efficient in segmenting aerial optic picture[4,5]. The goal of the adiabatic filter is to modify the SAR picture to obtain a picture more conform to the characteristics of an optical one. Hence, an optic picture has an additive noise. The use of coherent light in SAR picture produces an interference patern which looks like spikle in the picture. A higher surface albedo produces a more intense interference patern and more spikle in the image. This could be modelized by a multiplicative noise. Some more rigorous demonstrations could be found in[7].

The simplest way to transform the SAR noise model into an additive model is to calcul the logarithm of every pixels in the images.

$$\log(\text{signal}*\text{noise})=\log(\text{signal}+\log(\text{noise}) = \text{signal}' + \text{noise}'$$

After this transformation, the noise of the SAR image is still too high. The picture still need to be filtered.

There is some properties that are usefull to obtain a more general filter.

I) The noise level should be reduced (ie: the variance inside a segment must decrease)

2) The more information as possible should be preserved.(for example a filter which makes the Image uniform remouve all the noise as all the information.)

3) The filter should be fast. Because images are generally large (256 X 256 minimum).

4) A smaller number of needed parameter is better.

The filter employed in this article (called adiabatic) is the following.

1) take the log of each pixel in the image to form channel (1).

2) Add in a second channel the average over a 3 X 3 window of the chanal (1)

3) Add in a third channel the average over a 5 X 5 window of the chanal (1)

This filter satisfies all the four requests made above.

1) The noise level is effectively reduced . A sample square region of the image is taken and the resulting variances are:

image	variance.
log (original)	.3298
filter channel (1)	.3298
filter channel (2)	.1481
filter channel (3)	.0658
filter (average)	.1812

2) All the information is preserved. The original picture will be restored if the exp() of the first channel is taken.

3) The filtering by two square windows can be implemented with only 9 additions and two divisions by point. The filtering time is usually small compared with the segmentation process.

4) This filter does not require any parameter and could be used for any aerial radar image .

The chapter 4) shows the result obtained by the adiabatic filter and the HSO algorithm.

3) The HSO Algorithm.

A hierarchy of segments could be represented by a segment tree where the nodes correspond to the segments. Each segment S_i^k is linked to segments of the lower level, S_j^{k-1} .A picture partition thus corresponds to a sub-set of these tree nodes. HSO is a strictly agglomerative algorithm which merges similar segments . In this paper, the two most similar segments are the neighbor pair such that their merge produces the smallest increase of the sum of quadratic error.

The step wise criterion is:

$$C_{i,j} = \frac{N_i \times N_j}{N_i + N_j} (\mu_i + \mu_j)^2$$

where N_i is the size of the segment S_i and μ_i is its mean value. The utilization of $C_{i,j}$ in HSO ensures that each merge corresponds to a local minimisation of the total square error.

The HSO algorithm is described bellow as proposed by Beaulieu and Goldberg [4].

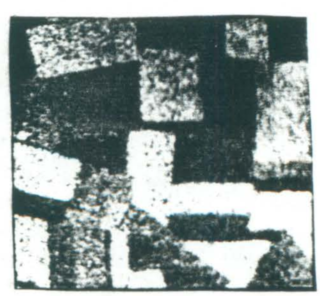
step i) Define an initial picture partition (here each pixel forms a segment).

step ii) For each adjacent segment pair, (S_i ,S_j), calculate the step wise criterion, $C_{i,j}$; then find and merge the segments with the minimum criterion value.

step iii) Stop if no more merges are needed ;otherwise go to ii).

Note that μ_i is ,in general, a vector with k element K being the number of chanals in the image.

figure 1



4)EXPERIMENTAL RESULTS.

Figure(1) represents an image taken the July 6, 1981 near Makofen in the Federal Republic of germany by the CCRS Convair 580 as part of the European SAR 580 Campain.[2]. The figure (2) presents the ground reality which contains 23 segments. Note that segment 14 is not discernable by visual examination and segment 18,19 and 20 seem to be merged togetger. The three last figures show segmentation images with 25 segments. They are obtained with the HSO algorithm using different filtering before the fusion. The number of 25 segments is chosen because it is slightly superior to the real number of segments . Thus in a good process, each real segment should be visible and some will be subdivised. Furthermore, for two of this pictures, 25 corresponds to a discontinuity in the first derivative of the criterion value as a function of the number of segments.

In the Figure (3) ,no filter has been used and the result is very poor .

In the Figure (4), the log of the image has been taken without any other filtering. Aera 17 has disappear. The aera 2 which is visible by visual examination is strongly subdivided . The part of aera 3 under aera 9 is strongly deformed. The region 12 has an out growing in to aera 11. Although this is not necessarily bad. By visual examination ,we might have done the same thing. At last, the aera 1 is merged with aera 3.

In the Figure (5) , the log is taken and an averaging window 5 X 5 is calculated over the image . The image is improved in many ways. Hence, the aera 3 under 9 is much more visible. The aera 9 is clearer. The aera 12 does not outgrow as much into the aera 11, and the aera 2 is less subdivided. But the aera 16 has desappered The use of a larger filter has blurred the edges . There are "artificial " regions which has grown at the frontiers of many real aeras.

In Figure (6), the full adiabatic filter is used. Except aeras 6 and 17 ,all other visible aeras are present and the edges are rather straight and never doubled. The places where the edges are not straight correspond to the most blurred regions of the image.

figure 2

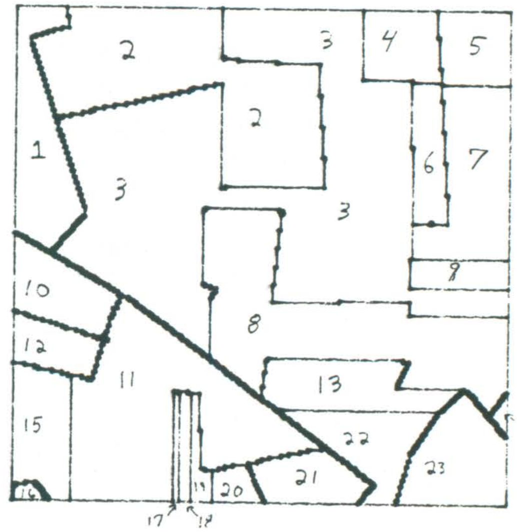


figure 3

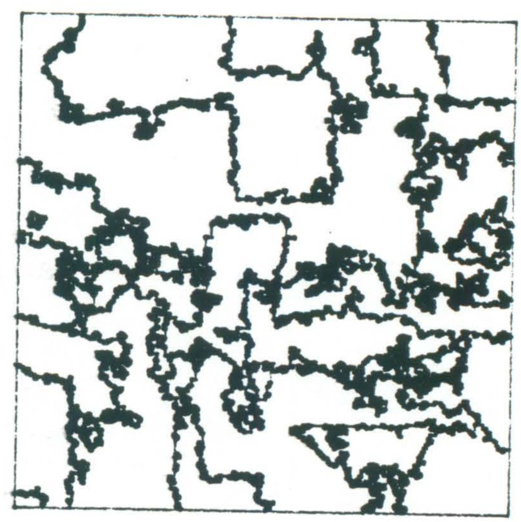


figure 4

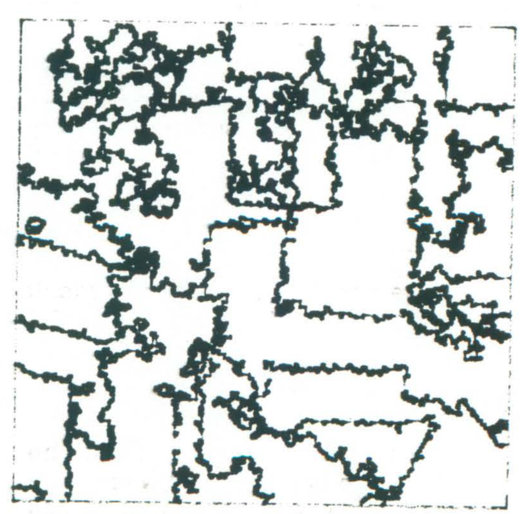


figure 5

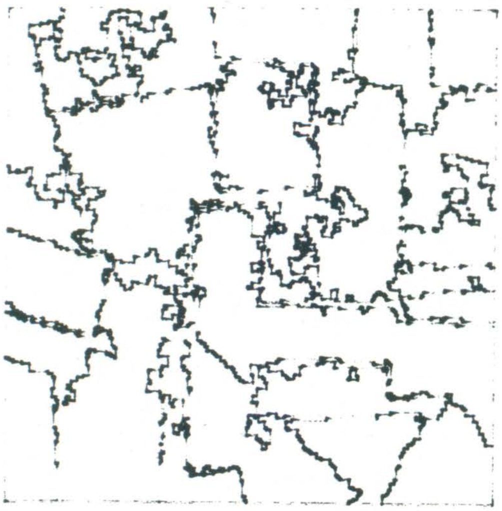
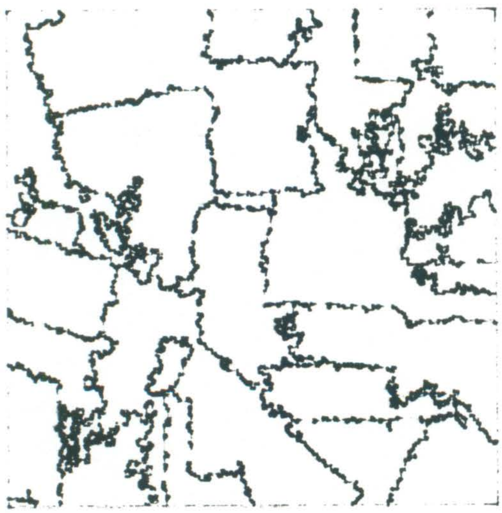


figure 6



5)CONCLUSION

A new filter, named adiabatic for its reversible property, is shown . Only two assumptions is made on the image processed.

Those absumption are : The image had a multiplicative noise (which is always a good approximation for SAR image) and the regions can be discriminated by the average of their pixels. This implies that no structured texture is present in the image. These assumptions are sufficently generals to fit a large number of remote sensing images . Therfore, the adiabatic filter used with the HSO algorithm is a valuable tool for segmenting SAR agricultural pictures. If the picture contain suburbs ,for example, the model of uniformity of region ought to utilize more complex criterion than the minimisation of the square error.

The most blurred aeras in the image have irregular edges. It is surely possible to use this property in order to make a better segmention of those aeras.

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