MULTI-SCALE SEGMENTATION OF VENUS SAR IMAGES

USING A MODIFIED WATERSHED

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Abstract -

➠ We develop an application to identify and characterize polygonal features in SAR images, based on a watershed algorithm, modified for a good robustness to radar noise.

➠ Our system performs a multi-scale analysis of the image. Oversegmentation is prevented by a selection of outstanding contours; regions with less prominent contours are merged

➠ This analysis is applied to Venus images from the Magellan mission. The system makes the distinction between polygonal and non-polygonal areas, and analyzes the polygons characteristics.

1. Introduction

The analysis of the Venus images provided by NASA's Magellan radar has revealed a number of zones with polygonal fractures [1][2]. These patterns may be related to past climatic changes. Their dimensions are consistent with specific variations in surface temperature [2]. Given the size of the Magellan database, the precise identification of all polygonal areas is too time-consuming for a team of geologists ; our goal is to automate this task.

2. The watershed algorithm

The watershed algorithm ([3], fig 2) considers the grey level image as a 2-dimensional landscape, and detects edges with an immersion simulation. Catchment basins are grown from the local minima of the grey level, until the whole image is covered. When two basins reach each other, a dam is erected. The set of dams form the detected contours. The connectivity of the lines defining the polygons makes the watershed a well-suited algorithm for the segmentation process involved in this study. Additionally, this method doesn't require any a priori knowledge on the properties of the image, therefore its use is easier than an analysis based on Markovian fields, like the one applied to the detection of roads networks on Earth [5].

3. Prevention of oversegmentation arising from the watershed method

- A first step in the prevention of oversegmentation is prefiltering. To remove the noise in the radar images, considered as a multiplicative noise and modeled by a Rayleigh law, we use a Lower-Upper-Middle (LUM) filter ([6], Fig. 1). This non-linear, rank-order-based filter has both smoothing and sharpening properties, and is thus useful to suppress speckle and to enhance the edges in the image.
- We then consider only the edges having the most important dynamics [4] : prior to the watershed, a pre-immersion is performed, so that small variations of the grey level, resulting in noise-related edges, disappear. The amount of water poured in the basins at this step of the segmentation has a strong effect on the size of the detected patterns. This parameter is set automatically, depending on the variation of contrast between the initial image, the LUM-filtered image, and a third image obtained by a morphologic erosion. We measure the contrast with Haralick criterion [7], and with the variance of the grey level in the image.

- Finally, the grey level of each edge is compared to the mean grey level of the two adjacent basins, the edges that are not outstanding enough are suppressed and the regions merged.

4. Multi-scale analysis

Two different scales are used for this analysis. A coarse resolution analysis provides the large and most apparent contours, then a fine resolution detects more precise lines and complementary patterns (fig 3). This multi-scale analysis is similar to a visual detection that would be performed by a human observer taking a first quick look at the picture, then searching for details.

5. Rejection of the image or acceptance of the result

In areas containing no polygonal faults, the distribution of the areas of the detected regions shows a high number of very small regions (due to remaining noise) and very large regions (due to little contrast), as well as regions having a highly variable interior brightness. Such regions are rejected by our application. When the result is kept, the connectivity of the detected lines allows easy identification of all edges and polygons. The polygonal features are characterized by their area, their largest and smallest distance between vertices (defining the elongation of the polygon), and their average number of edges per polygon. The main orientations of edges in the image are also computed (fig. 4.c), and a polygonal approximation of the image is realized.

6. Conclusion

In addition to the Venus images, our method can be applied to any other situation with radar images exhibiting closed patterns. We tested it successfully on Mars images of patterns in impact craters obtained by the Mars Global Surveyor mission, and Galileo pictures of meshes of lines on Europa. It can also be used in Earth imaging in field segmentation of agricultural images.

References :

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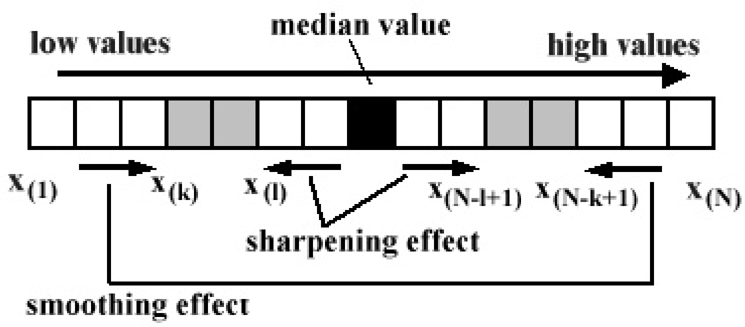

Fig 1: Diagram of LUM filters. The grey zones represent the values allowed for the output

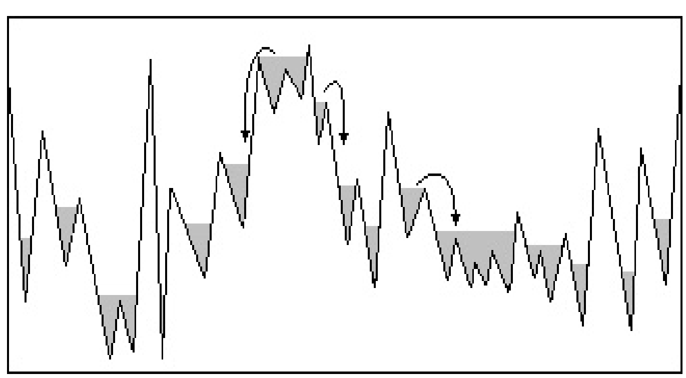

Fig 2: Schematic of the watershed process. The grey zones represent the water used for the pre-immersion.

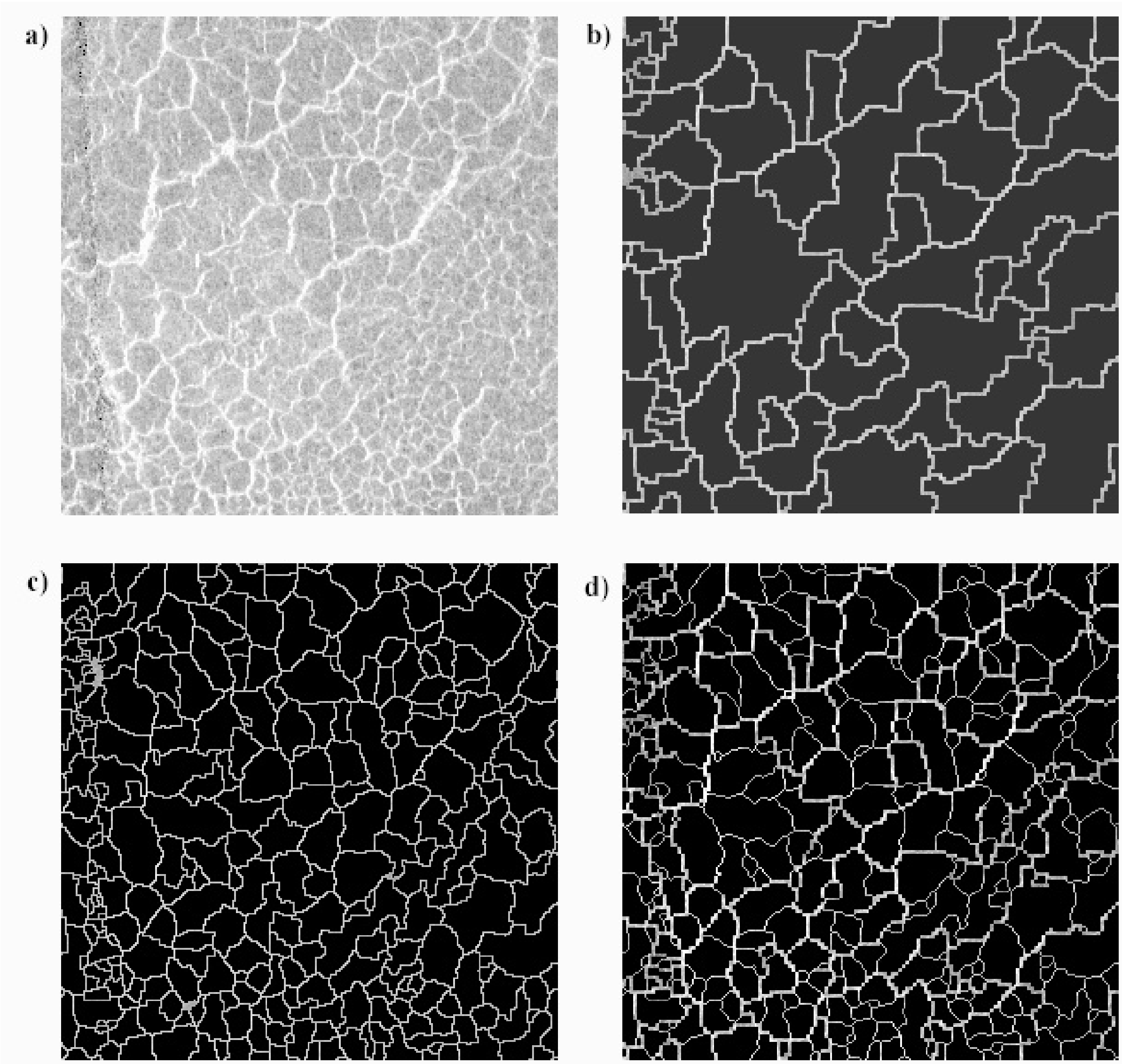

Fig 3: **a)** Venus "polygonal area" **b)** Edges obtained at coarse resolution
c) Edges obtained at fine resolution **d)** Fusion of coarse and fine resolution

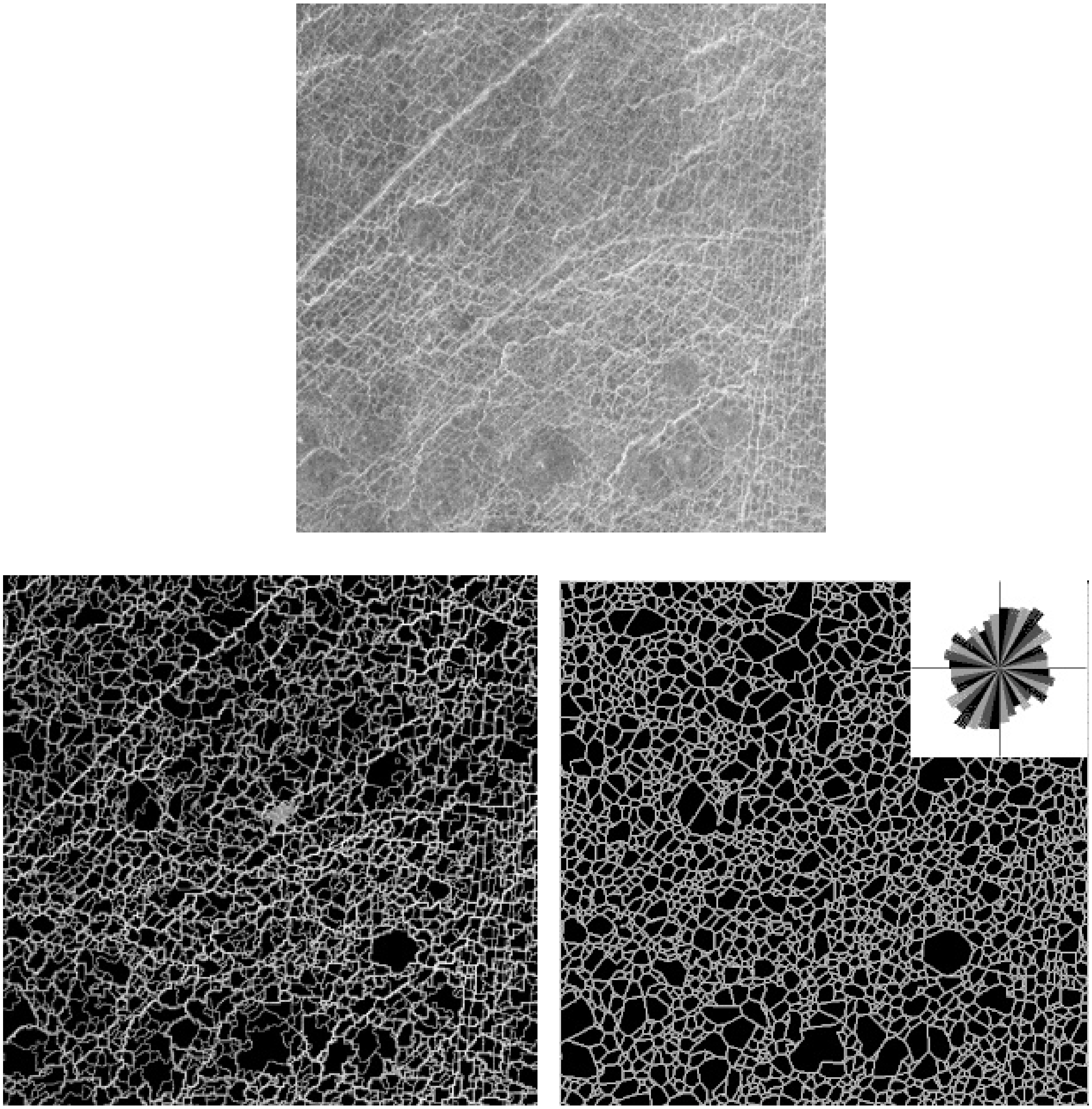

Fig 4 a) initial Magellan image

b) Result after merging the results obtained at the two resolutions. The coarse resolution provides the brightest lines whereas the fine resolution provides the fainter lines.

c) Polygonal approximation of the image. The figure also pictures the distribution of directions of the edges, the area of each sector is proportional to the number of edges having its orientation.