SEGMENTATION OF SATELLITE IMAGES BY MEANS OF MORPHOLOGICAL AND OBJECT-ORIENTED APPROACHES

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ABSTRACT:

Segmentation of satellite images is one of the main tasks that need to be solved in the process of detection of geometric forms belonging to distinct land covers. In recent years a great variety of methods for satellite images segmentation was developed. The aim of this study was compare applicability of two methods for image processing for information extraction from satellite images - namely object-oriented approach and mathematical morphological method. Mathematical Morphology is a geometric approach in image processing and analysis with a strong mathematical favor. Originally, it was developed as a powerful tool for shape analysis in binary and, later, satellite images. The second method considered is the multivariate segmentation realized by the eCognition package. This patented algorithm is used as starting point for comparison of the newly developed ones. Both methods were applied for segmentation of a satellite image of central Bulgarian region. The obtained results were compared and the advantages and disadvantages of morphological method are discussed. Conclusions about applicability of morphological methods for segmentation of satellite images are also made.

1. METHOD DESCRIPTION

Mathematical morphology is based strictly on the mathematical theory, and its initial idea is to explore the structure of image by putting a structure element into it (Cui, 1999). The basic morphological operators include erosion, dilation, opening, closing, which were first systematically examined by Matheron and Serra in 1960s, and other operators can be defined by the above basic operators. Mathematical Morphology has been applied successfully in many fields, such as medical imaging, material sciences, and machine vision (Cui, 1999), and many attempts were related to the processing of remotely sensed images, including segmentation (Pesaresi & Benediktsson, 2001), feature extraction (Talbot,1996; Vincent,1998; Katartzis, et.al, 2000), road network extraction on SAR image (Chanussot & Lambert, 1998) .

1.1 Watershed algorithm

The standard algorithm allowing the determination of these crest lines is the Watershed algorithm. It consists in a simulation of an immersion of the altitude map. To realize this, we make a hole at each local minimum of the gradient image by which the water can enter. The water level is then increased gradually in all basins. When the waters arriving from two different local minima meet, we decide to build a dam to avoid that they merge, as illustrated in Fig. 1. When the entire image is flooded, then these dams define segmentation.

In field of image processing and more particularity in Mathematical Morphology, grayscale images are often considered as topographic reliefs. In the topographic representation of a given image, the numerical value (i.e., the gray tone) of a each pixel stands for the elevation at this point. Such a representation is extremely useful, since it first allows one to better appreciate the effect of a given transformation on the image.

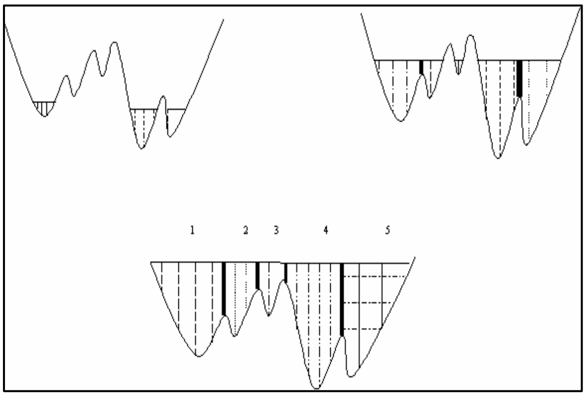

Figure 1. In the Watershed algorithm, we start flooding from the level zero. When two basins meet, we build a dam. At the end of the process, the dams define a segmentation

1.2 Watershed algorithm with a threshold

The principal problem with the Watershed algorithm is that we get an oversegmentation which can be explained by the presence of spurious local minima (Lamarechal, 1998). The main issue is then to eliminate the influence of these insignificant minima. The first modification consists in introducing an initial flooding level in the Watershed algorithm. In this way, all the edges which are present in the image produced by the original Watershed algorithm, and which have one or more gradient values below the threshold, will disappear.

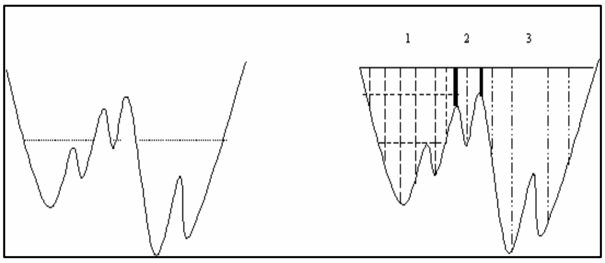

Figure 2, In the threshold algorithm, we do not start building dams before the threshold has been reached

n this study we using the algorithm that creates a binary image (f) by computing the regional minima of (f), according to the connectivity defined by the structuring element (B_C) . A regional minimum is a flat zone not surrounded by flat zones of lower gray values. A flat zone is a maximal connected component of a gray-scale image with same pixel values. The dynamics of regional minima is the minimum height a pixel has to climb in a walk to reach other regional minima with a higher dynamics. The area-dyn is the minimum area a catchment basin has to raise to reach other regional minima with higher area-dynamics. The volume-dyn is the minimum volume a catchment basin has to raise to reach other regional minima with a higher volume dynamics. E.g.

$$RMIN_{B_C}(f) = \left(1 \le \left(\left((f+1)\nabla_{B_C} f\right) - f\right)\right) \vee (f \le 0) \qquad (1)$$

Where: f = image undergoing processing
B_C = structuring element (variable parameter), which finally determinates the number of homogeneous regions in the image.

This algorithm helps us to create the image (f) by detecting the domain of the catchment basins of (f) indicated by the marker image (g), according to the connectivity defined by (Bc).

For comparison of the method described above the patented commercial software eCognition was utilized. The main reason for this selection was that one of the basic steps in using it is the segmentation process. The description of the capabilities of this package along with some of its applications could be found on the Web site of the company Definiens (Definiens, 2006).

2. DATA

The data used throughout this study are an extract of Landsat scene. The area covered by it is about 40 km^2 and its geographic location is in the central North part of Bulgaria. During the processing not all bands of the TM instrument were used, but only the grayscale images corresponding to bands TM3 and TM4. This choice was made since the most of the land cover is made-up by vegetation (wheat fields, vineyards, deciduous forests etc.) which is reliably discriminated in the mentioned bands (Mishev, 1986). The other types of land cover presented in the data (water, urban) are also easily delineated in these multispectral bands.

Other sources of data for this study were shape files from the Corine land cover project 1990 for Bulgaria. They were used as precise reference for land cover objects.

3. RESULTS

3.1 eCognition

In the table below varying with one of the essential parameters (scale) for the segmentation process different number of continuous regions was achieved. The closest to the reference (man-made segmentation) was produced with value 85of this parameter. This result could be interpreted only quantitatively since notion about the shape and areas of these regions could be obtained only by direct layering of the resulting images

	parameters			Number of regions
	Scale param.	Shape factor	Compactness/ Smoothness	
1.	70	0.1	0.5/0.5	295
2.	75	0.1	0.5/0.5	258
3.	78	0.1	0.5/0.5	241
4.	80	0.1	0.5/0.5	228
5.	**85**	**0.1**	**0.5/0.5**	**208**
6.	90	0.1	0.5/0.5	182

Table 1. Varying of scale parameter

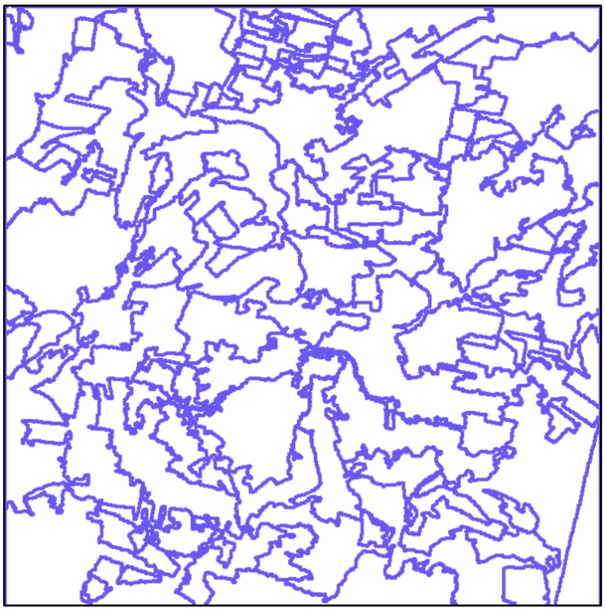

Figure 3. The segmented satellite image with scale=85

3.2 Watershed algorithm

In the table below are summarized the results obtained with several values of the structuring element. These values weren't set randomly, but were chosen from larger set – we started value of 10 and ended with value of 40. The number of areas in the image closest to the reference (man-made segmentation) was achieved with value 18.5 of this parameter. Here the number of segmented regions is slightly larger since even small areas (less than 2 km^2) were taken into account. Since the parameter B_C is the only possibility to control the segmentation better results (closer to the reference) could be obtained only by manually merging the small areas into larger ones.

	parameter Structuring element (B_C)	**Number of regions**
1.	17.5	400
2.	18	320
3.	**18.5**	**230**
4.	19	188
5.	20	140

Table 2. Varying of structuring element B_C

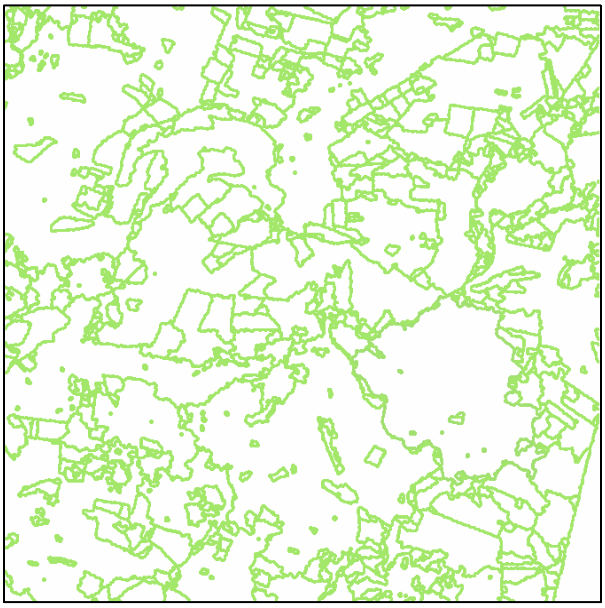

Figure 4. The segmented satellite image with B_C=18.5

On the Fig. 5 (see below) the output produced by both methods discussed above is shown – green is used for morphological segmentation and blue for this done by eCognition package. Although the number of regions is very close (230 and 208, respectively) most of the areas corresponding to vegetation (mostly for the grain crops) do not coincide, but for other land cover types such as water, urban parts the areas overlap. This might be product of the different approach implemented by these two methods. For the morphlogical method it is certain that it uses only the brightness values, but we are not aware what is considered by the segmentation in the eCognition package.

Figure 5. The segmented satellite image with B_C=18.5 and scale=85

4. CONCLUSION

Two methods were applied for segmentation of single bands of a satellite image. The results showed that even the number of regions is the same both methods produce areas with different shapes which overlap only some of the types of land cover. One possible inference that could be made is that some of the land cover classes could be segmented only by their brightness values in the spectral bands we have used. As a next step we plan to carry out experiments with spectral indexes and we expect that in this case better segmentation for the inadequately formed areas will be gained.

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