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Level Set Segmentation of Very High Spatial Resolution Satellite Image

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Abstract— **The advent of imaging very high spatial resolution has currently evolving representation of the study areas with high precision by providing a vision similar to that issued by the aerial images. However, their analysis requires new methods to deal with the multitude and diversity of information of information present in these images. Our contribution is to apply the level set method segmentation for very high spatial resolution. It is widely used in image processing field and has proven its effectiveness.**

Index Terms— **Remote sensing, satellite imaging with very high spatial resolution, segmentation, level set.**

I. INTRODUCTION

Remote sensing data acquired at very high spatial resolution (THRS) are of particular interest to get a more detailed maps, clearer, more beautiful and especially faster and less expensive to achieve. These images at very high resolution should be of great use for cartographers, but also for urban planners, farmers, and environmental managers, etc..

THRS imaging has revolutionized the satellite remote sensing to map the majority of objects composing a landscape or an urban area. Object detection techniques (extraction) and cutting images in different entities (segmentation) have a boom with results of variable quality requiring adaptations according to the investigated subject. In this context, there is provided here an image segmentation approach based on the method level set to identify desired spatial objects.

The segmentation is a process which extracts the outline of the ground objects by defining homogenous regions [1]. Thus, Segmentation partitions an image into distinct regions containing each pixels with similar attributes. To be meaning full and useful for image analysis and interpretation, the regions should strongly relate to depicted objects or features of interest. Meaning full segmentation is the first step from low-level image processing transforming a grey scale or colour image into one or more other images to high-level image description in terms of features, objects, and scenes. The success of image analysis depends on reliability of segmentation, but an accurate partitioning of an image is generally a very challenging problem[2].

Many techniques have been found, some more successful than others, but as we shall presently see, usually for a specific domain. The purpose of this writing is to test the level set method segmentation on THRS images. The rest of this article is organized as follows; Section II defines active contours, then Section III introduces the level set methods for image segmentation. Section IV describes the results of segmentation and Section V concludes the overall study.

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II. ACTIVECONTOURS

The general principle of the segmentation by active contours (sometimes called deformable models) consists in making an initial curve towards the borders of an object of interest, under the action of a force. In two dimensions, this approach results in the evolution of an initial curve in one frame to the structure to be segmented (Figure 1). For variational active contours, the evolution of the curve results from the minimization of a functional energy reflecting properties of the object to be segmented. [3] This approach was initially introduced by [4] with the model of snakes.

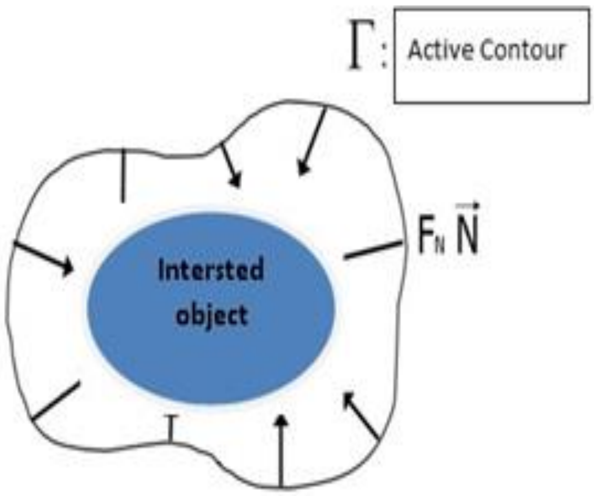

Figure 1. Principle of active contours segmentation

The active contour Γ moves towards the object of interest under the action of a force directed along the normal N to the contour.

There are two main approaches to active contours based on a mathematical implementation: the snakes and level sets. The snakes move explicitly a predefined set of points based on an energy minimization system [5]. While approaches of the level set move implicitly contours as a particular level of a function. More details on the approach level set will be discussed in section III respectively.

III. LEVELSET

The basic idea of the level sets method is to consider a curve (or interface) moving the zero level as a function of higher dimension [6] .The use of this type of representation to model a contour assets was initiated by Malladi[7].

Considering the equation of evolution of the active contour proposed in [8] we have:

$$\frac{\varphi\psi(x(t),t)}{\varphi} g \qquad F|\Delta\,(x\,(t), \quad t)| \quad = \quad 0$$

inconclusive. In what follows, we present some representative results using images of very high resolution of 1000 x 1000 in size and pieces. The manual segmentations images will reference segmentations. The first example uses the image of a lake to which the segmentation is used 3 times in each time modifying the parameters of the segmentation

Where ψ is the evolving of area, F represents the velocity of the curve, and g is known as the stop function.
In edge detection, the stop function g plays acrucial role. In fact, this function is the only connection between the curve and the image evolving. Thestop function is typically defined as a function of the gradient, and its expression is asfollows:

$$(z = \Delta I) = \frac{1}{1 + |\nabla\,(G * I|^{p}}, p \geq 1$$

Where I is the image intensity, $\nabla$is the gradient operator, and G * I is the convolution of the intensity image I by the Gaussian filter G. When we are in the presence of an edge, the gradient of the image is high, and the stopping function g takes a small value, inthis way stopping the evolution of thecurve The stopping function *g*(*z*) must have three properties [8] [9]:

1. Be definedpositive.
2. Have as maximum value1.
3. Be decreasing, and mustrespect

$$\lim_{z\to\infty} g(z) = 0$$

These three conditions must be met for the stop function properly integrates the equation of evolution.

IV. RESULTS ANDDISCUSSION

The methodology has been implemented in the environment Netbeans for the java programming language and an Intel Core I5 processor running at 1.6 GHz and 4 GB of RAM. The images used in the experiments are extracted from a QuickBird scene covering the region of Oran in Algeria and acquired as of 25/01/2010. The images have a size of 1000 x 1000 pixels, a spatial resolution of 0.6 meters and are composed of bands Green, Red and Near Infrared.

The proposed method of segmentation level set has been tested in several experiments and the results are

Figure 2. (a) Original image

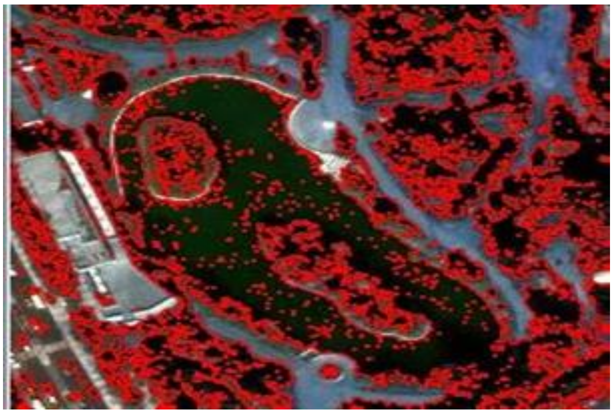

Figure 2. (b) segmented image delta 0.1 Phi = 3 number of iterations = 150

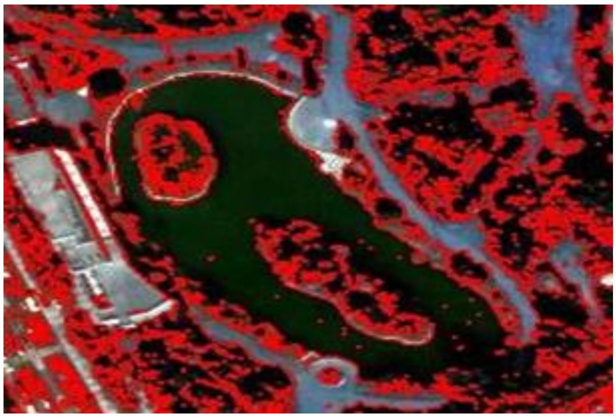

Figure 2. (c) segmented image delta=0.1 phi =3 number of iterations =100

Figure 2. (d) Segmented image delta =0.5 phi =5 number of iterations = 150.

Figure 3.(a) Original image

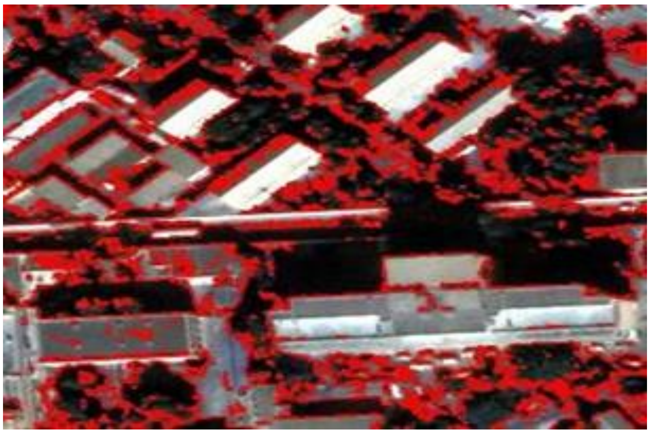

Figure 3.(b) Segmented image delta =0.1 Phi= 3 number of iterations =150

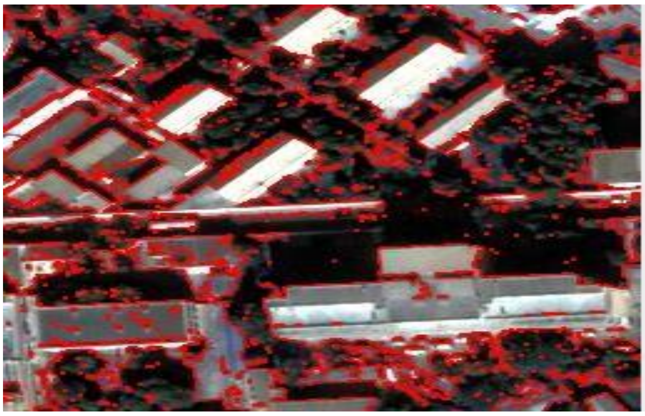

Figure 3. (c) Segmented image delta =0.1 phi =5 number of iterations = 150

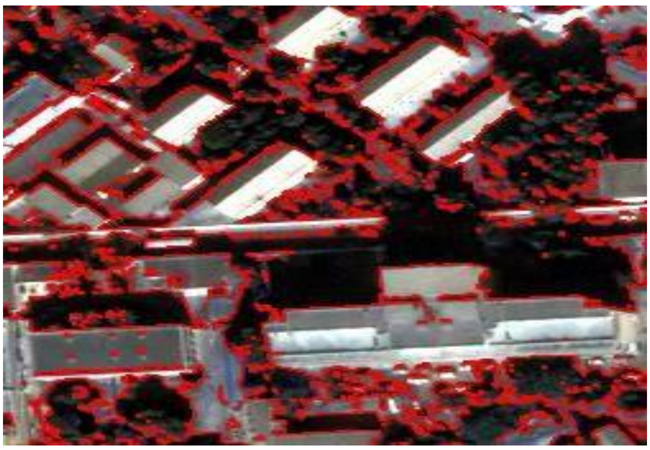

Figure 3.(d) Segmented image
phi =5 delta =5 number of iterations =200.

Figure 4.(a) Original image

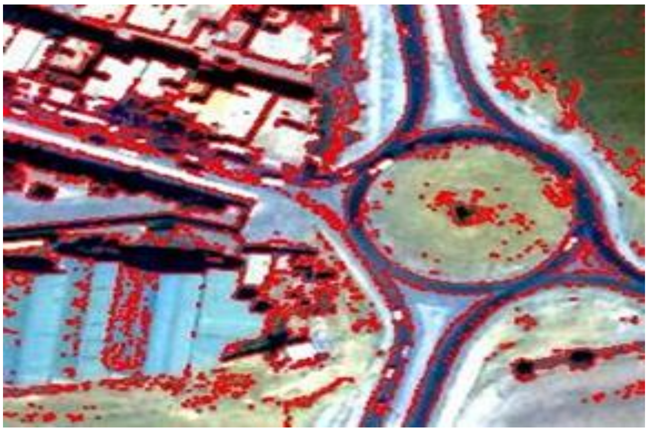

Figure 4. (b) Segmented image delta =0.1 phi= 5 number of iterations =150

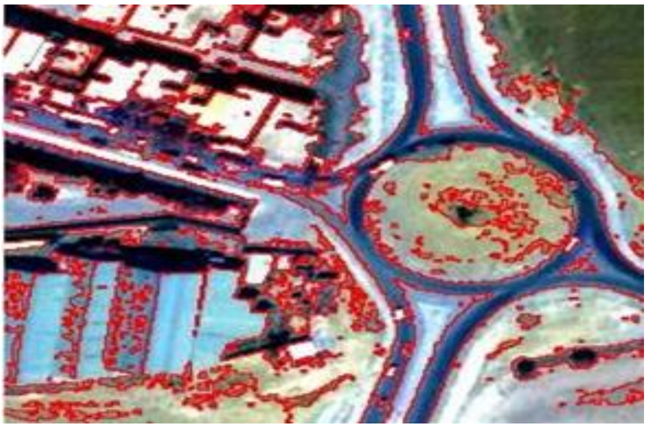

Figure 4.(c) segmented image delta =0.2 phi =5 number of iterations =150

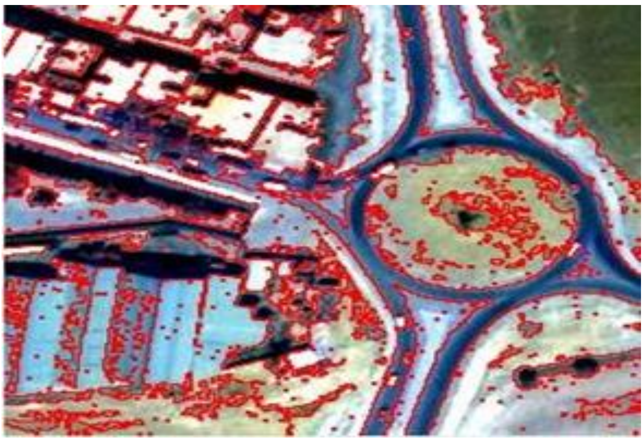

Figure4 (d) segmented image delta= 0.5 phi =5 long =0.0001 number of iterations =100.

The tables 1 and 2 below show the difference in surface rate calculated by the segmented objects method level set in km2 and segmented objects by an expert.

Table 1: Surface rate calculated by the segmented objects (a)

Objects	Reference image	Seg (a)	Rate
Lake	15.761	14.781	93.78%
Building	4.167	3.896	93.49%
Vegetation	7.008	6.891	98.33%

Table 2: Surface rate calculated by the segmented objects (b and c)

Objects	Seg (b)	Rate	Seg (c)	Rate
Lake	14.895	94.505%	15.12	95.93%
Building	3.953	94.864%	3.928	94.264%
Vegetation	6.951	99.186%	6.970	99.45%

According to the results of our approach and those obtained by the segmentation by an expert. We note that this method works well as it allows delimiting the contour of the different objects of high spatial resolution images. We also found that segmentation is good after 100 iterations (102584 milliseconds) for an image of size 1000 x 1000. This pushed us to be up to 200 iterations.

V. CONCLUSIONS

In this paper, we present a new approach for the segmentation of very high spatial resolution satellite image using active contours. Given the diversity of active contours, the choice fell on that of level set. Wehave applied our approach on a set of images and the results are interesting and can be improved. The main limitation of this approach is the adjustment of algorithm parameters. An adaptive setting is not obvious to implement but may be registered as a perspective to this work.

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