A Variational Level-Set Method for Unsupervised Change Detection in Remote Sensing Images

Yakoub Bazi* and Farid Melgani**

* College of Engineering, Al-Jouf University, Sakaka, Saudi Arabia
E-mail: yakoub.bazi@ju.edu.sa
** Dept. of Information Engineering and Computer Science, Univ. of Trento,
Via Sommarive, 14, I-38050 Trento, Italy
E-mail: melgani@disi.unitn.it

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ABSTRACT

A popular way to perform unsupervised change detection in multitemporal multispectral images consists to follow a two-step process. First, a couple of images acquired over the same geographical area at two different dates are co-registered and compared. The result of the comparison is an image usually termed "difference image". Second, changes are identified by partitioning the difference image into two regions associated to changed and unchanged classes, respectively. For such purpose, histogram-based thresholding techniques are usually adopted [1]. Despite their simplicity, in general, thresholding algorithms work well. However, they also can provide poor results especially when changed and unchanged classes are strongly overlapped or when their statistical distribution cannot be modeled accurately.

Recently, active contour models based on level set methods have gained popularity in image segmentation [2]-[4]. They exhibit interesting advantages over classical segmentation methods such as thresholding, edge-based, and region growing techniques. This can be explained by the fact that they achieve robust image segmentation thanks to the incorporation of prior knowledge within the energy minimization framework through which they are formulated. In addition, they can automatically handle topological changes thanks to the level-set method they are based on [5]. The segmentation process starts with an initial curve in the image. Then this curve is evolved by updating iteratively its position according to a speed function in order to minimize a predefined energy functional. The positions updates are obtained by solving differential equations. A common choice of the energy functional is the one proposed by Mumford and Shah known for its robustness against noise [6].

In this paper, we propose to solve the change detection problem by means of a variational level set segmentation method. In particular, we consider the piecewise constant approximation Mumford-Shah segmentation model for the difference image [2]. The minimization of this functional energy is made by a level set method, which seeks to find an optimal curve which splits the image into two mutually exclusive regions associated with changed and unchanged classes, respectively. Depending on the initialization of the level set functions, the energy functional may be trapped in a bad local minimum solution, thus affecting the quality of the final segmentation result.

To deal with this initialization issue, we use a multiresolution approach which aims at analyzing the image at different resolutions, namely from coarse to fine resolutions by successively down-sampling the image with a factor of 2. First, the curve is evolved in the coarse resolution image up to convergence. Second, the resulting curve is interpolated and up-sampled by a factor of 2 to create an initial curve for the next resolution, which in turn is updated with the same procedure until convergence. This iterative process is repeated over all the different considered resolutions until reaching the original image resolution stage. Operating in this way does not only increase the robustness of the segmentation procedure but decreases also the computation burden by making faster the convergence of the level set function as suitable initializations are obtained for each level.

In order to assess the proposed change detection method, two multispectral remote sensing datasets were considered in the experiments. The first one represents two low resolution images acquired in August and September 1994 over the Elba Island, Italy, by the Landsat-5 TM sensor. The second dataset is formed of two high resolution images acquired over the region of Mina, Saudi Arabia, in January and December 2007 by the IKONOS-2 sensor. The experimental results obtained on both datasets confirm the superiority of the variational level set method compared to the state-of-the-art change detection methods.

Keywords: Active contour segmentation, energy minimization, level set method, Mumford-Shah model, unsupervised change detection.

REFERENCES

[1] F. Melgani and Y. Bazi, "Markovian fusion approach to robust unsupervised change detection in remotely sensed imagery", *IEEE Geosc. and Remote Sensing letters*, vol. 3, pp. 457-461, 2006

[2] T. Chan and L. Vese, "Active contours without edges", *IEEE Trans. Image Process.,* vol. 10, pp. 266-277, 2001.

[3] Y. Shi and W. C. Karl, "A real time algorithm for the approximation of the level-set based curve evolution", *IEEE Trans. Image Process.,* vol. 17, pp. 645-656, 2008.

[4] I. B. Ayed, and A. Mitiche, "A region prior for variational level set image segmentation", *IEEE Trans. Image Process.,* vol. 17, pp. 2301-2311, 2008.

[5] S. Osher and J. A. Sethian, "Fronts propagating with curvature-dependent speed: Algorithms based on Hamilton-Jacobi formulations", *J. Comput. Phys*., vol. 79, pp. 12-49, 1988.

[6] D. Mumford and J. Shah, "Optimal approximation by piecewise smooth functionals and associated variational problems", Comm. Pure Appl. Math., vol. 42, 577-685, 1989.