Segmentation of 3D Structures in Volume Images Using Higher Order Active Contours

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**Topic Description:**
When human observers are interpreting images, they are not only taking into account direct observations like color or intensity, but also a priori knowledge about the world. However, such a complex, interacting method is rarely used in image processing systems. Most of the algorithms are bottom-up: they try to extract some useful information (basically a segmentation) solely from the observed image data and then the segmentation is interpreted. Obviously, image data alone cannot provide reliable information. Hence the use of higher level knowledge, in the form of shape priors, received more attention in the past few years. The dominating approach adopts a variational or level set framework where the segmentation criteria is summarized in an energy functional which takes its minimum at the desired segmentation of the input image. Previous work concentrated on foreground - background segmentation with a data model relying on image gradient and with template-like shape priors where the actual contour is matched to a reference shape and high deviations were penalized. However, handling of more than one, possibly different objects in a scene remains a challenge as well as the use of more elaborated data models, especially in the area of volume image processing. Here we propose to extend the idea of Higher Order Active Contours (HOAC) for 3D volume image segmentation. In a HOAC model basic geometrical constraints are modeled by quadratic energy functionals in a level set framework. The method has been successfully applied to road extraction from satellite images using a prior which favors network-like objects as well as to tree crown extraction using a “gas of circles” prior.

Specific aims of the proposed work:
1. Studying the possible 3D generalizations of the HOAC model.  
2. Stability analysis of the 3D model which constraints the possible parameter settings for a given 3D shape prior.  
3. Development of efficient data likelihood models and their integration into the 3D HOAC framework.  
4. The proposed solution will have applications to problems of interest in a wide range of areas, such as automatic segmentation of medical images, analysis of nanostructures in electron-microscopic images, or trajectory detection in temporal volume images (i.e. video sequences).

**Collaboration:** The proposed research is closely related to our collaboration with the ARIANA research group at INRIA, Sophia Antipolis, France.

**Admissible number of students:** 1  
**Deadline for applications:** 2016-09-30

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