A Method for Accurate Localization of Surfaces in 3D Medical Images [1]

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In this work, we are primarily concerned with the accurate and fast segmentation of 3D medical images. The presence of a significant amount of noise in such images makes known segmentation methods suffer of either lack of localization accuracy or oversegmentation. Among different segmentation approaches, we consider differential methods such as gradient filters [2] or Laplacian after Gaussian smoothing (LoG). In the latter case, the use of a filter with large σ reduces the noise but results in poor localization of edges, while a small σ gives better localization accuracy at the cost of oversegmentation. Consequently, one of the fundamental trade-offs in image segmentation is that of localization accuracy versus oversegmentation.

In this paper, we propose a method for the accurate localization of edges, which simultaneously reduces the effects of oversegmentation. The computational complexity of this method is also considered as a decisive factor.

The subtasks of this method are shown in Figure 1.

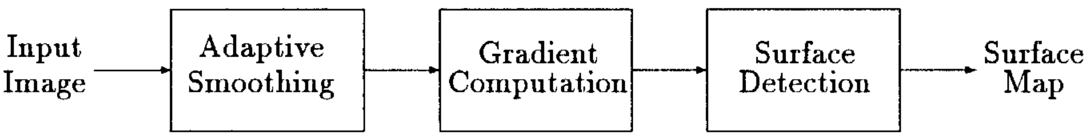

Figure 1: Subtasks of proposed 3D segmentation method.

First, adaptive smoothing is applied to the input image to reduce noise, without affecting the localization of edges. The smoothing filter is controlled by the local gradient and smoothing is performed only on those regions with low gradient. This phase uses a naive gradient approximation such as discrete differences in order to minimize computation time. Edge sharpening is also obtained as a side effect of intra-region smoothing [1].

After this first noise reduction step, "sharp" gradient operators, such as LoG or Deriche filtering with small σ or large α respectively, can be applied to the smoothed image, yielding better edge localization. In our implementation of the above method,

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the Deriche filter has been used in the gradient computation phase because of its computationally efficient recursive implementation, which is independent of the scale parameter α [2].

After the gradient is computed, its local maxima have to be tracked in order to locate the edges of the input image. Several methods have been proposed todate, such as hysteresis thresholding, watersheds etc. The basic criteria for the choice of an algorithm for this step were closure and thinness of the boundaries. The Watersheds algorithm [3] guaranties both of these properties. Oversegmentation, which is a known drawback of this algorithm, is reduced by the initial adaptive smoothing. Furthermore, its computational efficiency contributes toward an efficient integrated method for the accurate and robust segmentation of 3D medical images.

The selection of the proper input parameter values for each subtask is an open problem which is currently under investigation in our laboratory. Methods which select these parameter values based on input image characteristics have been investigated.

Segmentation results obtained with the proposed method for a synthetic and an actual MRI 3D data set will be presented and discussed.

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References

[1] P. Saint-Marc, J.S. Chen, G. Medioni, *Adaptive Smoothing : A General Tool for Early Vision.* IEEE Trans. on Patt. Anal. Machine Intell., Vol. 13, No. 6 , June 1991, pp. 583-598.

[2] O. Monga, R. Deriche, J.M. Rocchisani *3D Edge Detection Using Recursive Filtering: Application to Scanner Images* CVGIP. vol. 53, No. 1, January 1991, pp. 76-87.

[3] L. Vincent and P. Soille, *Watersheds in Digital Spaces: An Efficient Algorithm Based on Immersion Simulations* IEEE Trans. on Patt. Anal. Machine Intell., Vol. 13, No. 6, June 1991, pp. 514-529.