

4.5.27. IMPLICIT ACTIVE CONTOURS APPLIED TO THE FETAL ECHOCARDIOGRAPHIC IMAGES SEGMENTATION: A COMPARATIVE STUDY

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The segmentation of medical images, namely cardiac echocardiographic images of newborns allows physicians to identify several congenital heart defects like: i) Septal defects – Nowadays, many atrial and ventricular defects may be treated through percutaneous closure, several echocardiographic parameters should be analysed beforehand in order to determine the feasibility of the procedure: defect dimension and configuration, distances between defect borders and specific cardiac structures; (ii) Valvular malformation – In the case of Ebstein anomaly or cleft mitral valve, 3D echocardiographic images offer intracavitary perspectives of the valves, allowing a detailed analysis of their morphology, as well as coaptation mechanism and valvular regurgitation, if present; (iii) Aorta coarctation – 3D echocardiography permits endoluminal reconstructions of the coarctation and dynamic measurements of the lesion during the cardiac cycle.

The quantification of segmented structures and their morphological and physiological parameters are useful for future decisions concerning therapeutic management: catheterism versus surgery intervention. Also, image segmentation is often a necessary processing step for three-dimensional (3D) image reconstruction and quantitative analysis.

Active contours are among the most successful image segmentation techniques used in a variety of applications, such as computer vision, pattern recognition, and biomedical image processing. As image segmentation methods, there are two kinds of active contour models according to the force evolving the contours: edge- and region-based. Edge-based active contours use an edge detector, usually based on the image gradient, to find the boundaries of sub-regions and to attract the contours to the detected boundaries. Examples of such models are balloon models [3, 4], geodesic active contours [1], and geometric active contours [2]. Nevertheless the active contour may leak out of the ideal contour when the edges are weak.

Region-based active contours use the statistical information of image intensity within each subset instead of searching geometrical boundaries. Most region-based active contour models consist of two parts: the regularity part, which determines the smooth shape of contours, and the energy minimization part, which searches for uniformity of a desired feature within a subset. The initial contours can be located anywhere in the image as region-based segmentation relies on the global energy minimization rather than local energy minimization. In this work we compare the piecewise-constant active contour model proposed by Chan and Vese [1] using the Mumford-Shah segmentation model [2], and the new variational formulation for geometric active contours that forces the level set function to be close to a signed distance function, eliminating the need of the re-initialization procedure [3]. Parameters like position, shape, and propagation direction of level set, are considered in the study.

Also, as an important goal, we evaluate the performance of the two approaches to detect interior contours starting with only one initialization curve, using images with and

without smoothing. Figures 1 and 2 show the performance of the two algorithms for a rectangular initial contour.

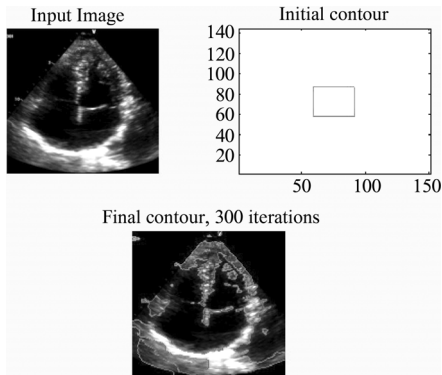


Fig. 1. Active contour without re-initialization [3]

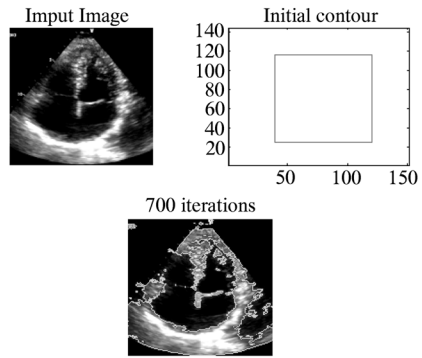


Fig. 2. Active contour proposed by Chan

References:

1. **Chan T. and Vese L.** Active contours without edges, IEEE Transactions on Image Processing, no. 2, pp. 266 – 277, 2001.
2. **Mumford D., Shah J.** Boundary detection by minimizing functionals, in Proc. of IEEE Conference on Computer Vision and Pattern Recognition, 1985.
3. **Chunming Li, Chenyang Xu, Changfeng Gui, and Martin D. Fox.** Level Set Evolution Without Re-initialization: A New Variational Formulation”, in Proc. of the 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR’05).