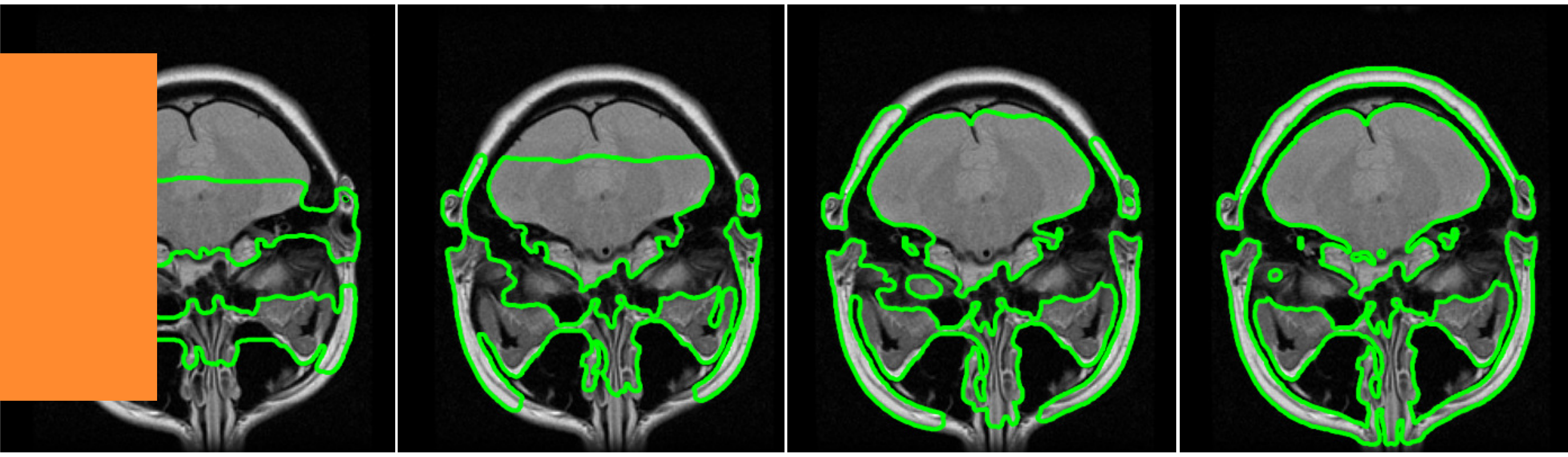
# Medical Imaging

## Segmentation with Level Sets



Contour propagation by initial conditions (40, 100, 150 and 200 iterations)

Segmentation (i.e. delineation of anatomical structures in image data) plays a crucial role in medical imaging. Due to the complexity and variability of anatomic shapes segmentation is still a big challenge.
A wide variety of segmentation techniques have been proposed: a) traditional low-level image processing techniques [1] which consider only local information and generates infeasible object boundaries and b) more robust techniques with deformable models [2] which exploits constraints from the image data (bottom-up) together with "a priori" knowledge about the shape (top-down).
The Institute for Medical and Analytical Technologies is focusing in the field of Medical Imaging on Data-Visualization, -Analysis and Modeling. The study of segmentation tech-niques is therefore a fundamental issue.
For efficient and robust segmentation of various anatomic structures we implemented the Chan-Vese- algorithm (a deformable model with Level Sets).

**Algorithm**

The Chan-Vese algorithm is an deformable model approach with contour evolution based on the Mumford-Shah functional, and the level sets of Osher and Sethian. A comprehensive description is given in [3].

$$E[C] := \lambda_{in} \cdot \int_{\Omega_{in}} (I(x) - c_{in})^2 + \lambda_{out} \cdot \int_{\Omega_{out}} (I(x) - c_{out})^2 + \gamma \cdot L_C$$

Given a gray-value image $I(x) : \Omega \rightarrow R^+$, the Chan- Vase algorithm minimizes the energy to define the contour $C$ that partitions the image domain $\Omega$ into two subdomains $\Omega_{in}$, $\Omega_{out}$ (where $C_{in}$, $C_{out}$ are the average gray-values in the sub-domains, $L_C$ is the length of the contour $C$ and $\lambda_{in}$, $\lambda_{out}$ , $\gamma$ are design parameters).
The propagation of C (on $R^2$) is solved by using Euler-Lagrange (PDE on $R^2$) and approxi-mation (Interation).

**Results Conclusion**

First applications with specific anatomical structures (brain, vessels, spine) led to robust and accurate segmentation results. And a strength of the algorithm is its ability to handle the topology changes (level sets).

Due to the inability to distinguish between different shapes (no model-information) the algorithm is mainly useful for semi-automated segmentation.

References:
[1] Bezdek, J.C., et .al.:Review of MR image segmentation techniques unsing pattern recognition. Med.Phys., vol. 20, no4, 1993.
[2] McInerney, T., Trezopoulos,D.: Deformable models in medical image analysis: A survey. Medical Image Analysis 1 (2) :91-108, 1999.
[3] T. Chan and L. Vese. An active contour model without edges. Int. Conf. Scale-Space Theories in Computer Vision, 16(2):266-277, 1999.

We invite you to explore and develop new ideas together with us!

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