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Automatic segmentation of 3D high-resolution image by deformable models

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"Image segmentation" which consists in delineating a Region of Interest is in general a requirement before any analysis of image data. This step is all the more critical as its accuracy may impact the validity of the entire processing pipeline. However, commercial image processing software proposes few tools and most of them are based on quite basic principles as thresholding, region growing or mathematical morphology. Accordingly, segmentation is often performed interactively with much manual intervention. This process is long and overall user-dependent.

In the case of micro-CT data where the size of the image becomes huge (e.g. 2000 slices of 2000 x 2000 pixels), manual segmentation can take days which prevents from analyzing large sets of data. Moreover, at a resolution of 10 to 100 microns, so many details are visible that it may be difficult to follow a boundary of Region of Interest along the slices. Automatic segmentation methods are then required to be able to process the ever-increasing number of high-resolution 3D images acquired for biomedical, geoscience or palaeoscience applications.

One of the most efficient methods is called "deformable model". Deformable models are surfaces (or curves) which are plunged in the 3D image and deform under the influence of internal forces, which are defined within the surface itself, and external forces, which are based on features which are extracted in the image. The internal forces are designed to keep the model smooth or near a given reference shape during deformation. The external forces are in general defied to attract the model toward image discontinuities. By integrating a-priori information about the shape and global image data in a consistent mathematical description, deformable models offer robustness to image noise, low contrasted boundaries or partial volume artifact.

We will show some examples in medical and paleo-anthropological applications as automatic segmentation of endocast or musculoskeletal structures.

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