A PATIENT-SPECIFIC AUTOMATIC SEGMENTATION OF THE FEMUR BONE BASED IN 3D ACTIVE CONTOURS

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Introduction

Image segmentation is a computational technique which returns the division of a given image into multiple pixel regions, according to a specific characteristic or computational feature. In Medical Imaging, this process is of major importance since it allows the automatic detection of tumours, a computer-aided surgical procedure or merely the acquisition of a 3D model of a specific bone or organ, as seen in the present study. The iteration starts with rough estimate of the femur bone contours which is allowed to deform so as to minimize a given energy functional in order to produce the desired segmentation. This pipeline was implemented in a level set framework [Osher, 1988] due to its high flexibility and easiness to adapt to different problems and its ability to deal with changes in the topology of the contours. This energy functional was designed to take advantage of both the region-based and edge-based active contours. On the one hand, edge-based contours dismiss the placement of global constrains, which allows the background and foreground to be heterogeneous. On the other hand, region-based contours add both robustness against the initial placement of the contour and insensitivity to the noise of the acquired data to the method. Due to the complexity of the segmentation in the proximal region of the femur, more specifically, in the region of the head of the femur, it can be necessary to include *a priori* information about the shape and orientation of the volume to segment into the energy functional. The final result of the proposed method is a reliable 3D representation of the patient-specific femur which may easily be exported to a stereolithography or a Finite Element mesh.

Methods

The energy functional E of the signed distance ϕ, the evolution of the iterative process may be represented by:

$$\int_x \delta\phi(x) \int_y \mathrm{B}(x,y) \cdot F\big(I(y), \phi(y)\big) dydx \quad (1)$$

where $\delta\phi(x)$ specifies the neighbourhood of the surface limits, $\mathrm{B}(x,y)$ [Lankton, 2008] represents a sphere of radius *r* and centered in the contour point *x* and *F* is a generic force function used to measure the local adherence to a given model along the contour. This force can easily represent any region-based contour energy, although for the present study only Chan-Vese [Chan, 2001] and Yezzi [Yezzi, 1999] were implemented.

Results

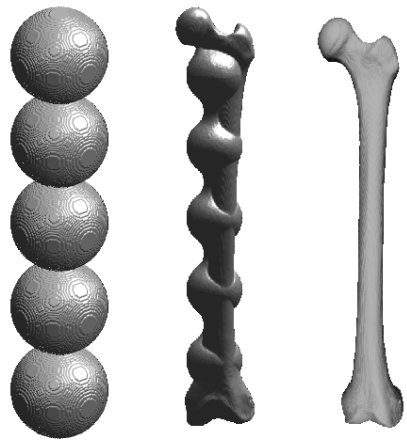

Figure 1: On the left, the initial mask of the contour; on the center, an intermediate state of the iterative process and on the right the final result.

Discussion

A fully automated patient-specific segmentation of the human femur bone was achieved based in the active contours technique. The resulting 3D volume is an excellent starting point to further studies, such as Finite Element analysis.

References

Chan, T., Vese, L., IEEE Trans. Ima. Proc. 10, No. 2, 2001.
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Osher, S., Sethian, J, J. Comp. Physics, 79: 12-49, 1988.
Yezzi, A. *et al*, Proc. Int. Conf. Comp. Vis., 2:898-903, 1999.