CEMRACS 2018 PROJECT

Geometry description and mesh construction from medical imaging data

An ever increasing research effort is aimed at the simulation of patient-specific biophysical phenomena. Clearly, a key step towards this goal is to provide efficient algorithms for defining and meshing the (patient specific) domain in which the simulation will take place.
Our project aims at providing the geometry description and a good quality mesh of the patient specific domain where subsequently some kind of PDE describing the phenomenon at hand will be solved. This needs to be dome by relying on the data available, which normally comes from some kind of medical imaging. The approach that we will follow is based on Atlas Based Segmentation, a technique where the image is segmented by performing a registration with a pre-segmented image that takes into account neighbourhood relationships between the different parts of the anatomical structure that one needs to reconstruct, and that is marked with labels, identifying the different parts of the anatomy (the “atlas"). The registration step yields a map from the atlas to the image to be segmented, which then inherits labels and segmentation. Taking this idea one step further, if, starting from the atlas one builds a geometry description and a mesh, the map allows to obtain geometry description and mesh for to the image at hand.

The overall procedure consists in several steps.

1. Building the atlas: several techniques are available, the atlas can be built by a single or multiple raw images, and this entails a segmentation and labelling step to be performed either by hand or by some automated technique (or by a combination of the two).

2. Constructing a “model” description of the geometry and a volumetric mesh.

3. Given a patient specific image, register it with the atlas, and obtain a map from the atlas to the image (with consequent labelling and segmentation of the image)

4. Construct the new, patient specific, geometry description and mesh by applying the map to the “model" geometry.

During CEMRACS 2018 we plan to attack steps 3. and, possibly, 4. The registration algorithms that we are going to consider will be based on a new image metric, the Wavelet Normalized Root Mean Square Error (WNRMSE), proposed and analysed in [1]. Such a metric has an intrinsic noise reduction mechanism which makes it particularly well suited for registration in a noisy environment. Such a metric has already been tested for registration of 2D medical images, and we plan to extend it to three dimensions an test it on an atlas based segmentation task.

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[1] T. Rohlfing, R. Brandt, R. Menzel, D.B. Russakoff, and C.R. Maurer, Jr., *Quo vadis*, Atlas Based segmentation, in J. Suri, D. L. Wilson, and S. Laxminarayan (eds.), *The Handbook of Medical Image Analysis: Segmentation and Registration Models*, Kluwer, 2007

[2] M.G. Albanesi, R. Amadeo, S. Bertoluzza, G. Maggi, A new class of wavelet-based metrics for image similarity assessment. Journal of Mathematical Imaging and Vision, Vol. 60, Issue 1, pp 109–127