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Vessel Segmentation on Computed Tomography Angiography (CTA)

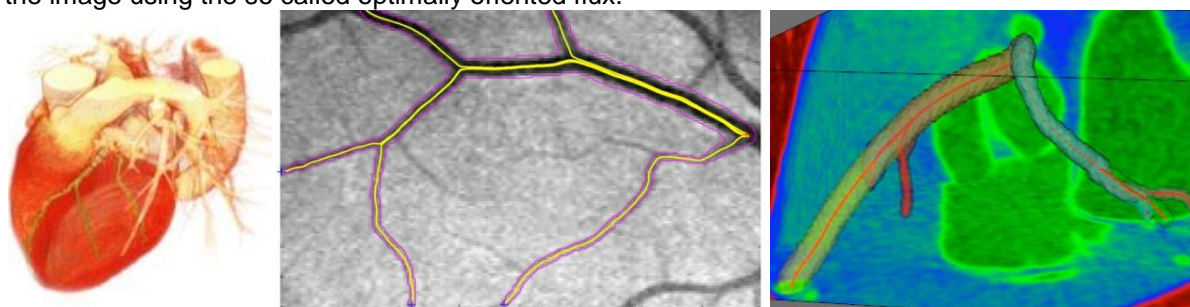
French Partners: Laurent D. Cohen and Fethallah Benmansour, CEREMADE, Université Paris Dauphine; Philippe Douek, Maciej Orkisz, Maria Alejandra Zuluaga and Eduardo Davila, Creatis Lyon.
Israeli Partners : Ron Kimmel and Alexander Brook, Technion; Nir Sochen, Tel Aviv University.



This short paper describes our contribution in the research aimed at model based vessel segmentation on CTA. Although each partner was involved in a main subject among what follows, the contribution is a joint effort of all the partners, as a result of regular visits in France and Israel, as well as between partners in each country.

The French Hospital Partner in Lyon provided a large set of CTA studies, including sets with two studies performed on each patient and about 20 studies suitable for work on other aspects of cardiac vessel segmentation.

The partner in Paris has a long experience of vessel segmentation and improved, in the framework of this project, an approach based on minimal paths and front propagation for 3D vascular tree segmentation and on tubular anisotropy. The key is to represent the trajectory of the vessel not as a 3D curve but to go up a dimension and represent the entire vessel as a 4D curve, where each point represents a 3D sphere (three coordinates for the center point and one for the radius). The 3D vessel structure is then obtained as the envelope of the family of spheres traversed along this 4D curve. Since this 3D surface is defined simply from a 4D curve, we are able to fully exploit minimal path techniques to obtain globally minimizing trajectories between two or more user supplied points in order to reconstruct vessels from noisy or low contrasted 3D data. This approach has the advantage of not being sensitive to local minima inherent in most active surface techniques. This 4D curve yields a natural notion of a vessel's centerline and its envelope which corresponds to the boundary of the vessel. An important aspect of our approach consists in building a multi-resolution metric that guides the propagation in this 4D space. This means we extract the local geometry (orientation and scale) of the image using the so called optimally oriented flux.



With partners in Lyon (CREATIS team), we developed an interactive tool for minimal interaction vessel segmentation based on their black box toolkit (BBTK). This tool is useful for the physician in order to obtain a segmentation of a vascular tree and centerline paths that enable to make efficient visualization and to allow the clinician to perform a quantitative assessment of the vessel morphology. The Israeli partners focused on the creation of a rough shape prior model for segmentation invariant under non-rigid transformations. With cardiac CTA usage on the rise, there appeared a growing population of patients who underwent more than one CTA study. Our initial proposal was to use the segmentation from the first study to automate the segmentation of the subsequent studies. We have adopted a representation similar to that described above for minimal paths, where a vessel is described by the centerline and the radius at each point. We developed an algorithm which, given an existing segmentation, register it with another study, thus providing an automatic segmentation. The algorithm progresses from the proximal end of the vessel distally, predicting the next point based in the existing segmentation and then correcting it based on the image data.

In conclusion, we have proposed minimally interactive methods for vessels and vascular tree segmentation (tubular branching structures), where the user provides only one initial point. These are used for shape prior segmentation allowing non rigid deformation of the surface.

Publications can be found on the website <http://www.ceremade.dauphine.fr/~cohen/recentpub2.html>