FROM MEDICAL IMAGES TO NUMERICAL BLOOD FLOW SIMULATIONS IN HUMAN VESSELS

I. Mallabiabarrena[1], C. Prud'homme[2] , A. Radaelli[3], V. Rigamonti[4] and D. Sage[5]

[1]Cardiovascular Surgery Dept., CHUV, Lausanne, Switzerland; [2]Modelling and Scientific Computing Group, EPFL, Lausanne, Switzerland; [3]Dept. of Aeronautics, Imperial College, London, U. K.; [4]MOX, Politecnico di Milano,Milan, Italy; [5]Biomedical Imaging Group, EPFL, Lausanne.

INTRODUCTION: Computational fluid dynamics (CFD) techniques are becoming more and more mainstream in the cardiovascular research. It is an important tool to better understand blood flow characteristics, wall shear stresses, and recirculation zones in the arterial wall regions which are usually very difficult information to obtain in vivo. However providing these detailed descriptions on a patient basis is very complex, in particular due to the wide variety of individual vascular morphologies.

The pre-processing of the clinical data to define properly the real patient based geometry model is a crucial step to obtain meaningful results. This step requires the support of modern medical imaging techniques (MRI, CT, Doppler) and 3D geometrical reconstructions algorithms.

In this work, we focus on these algorithms and present a first open-source prototype of the preprocessing steps (Fig 1). The numerical simulation is done by the tools developed in the LifeV[1] project.

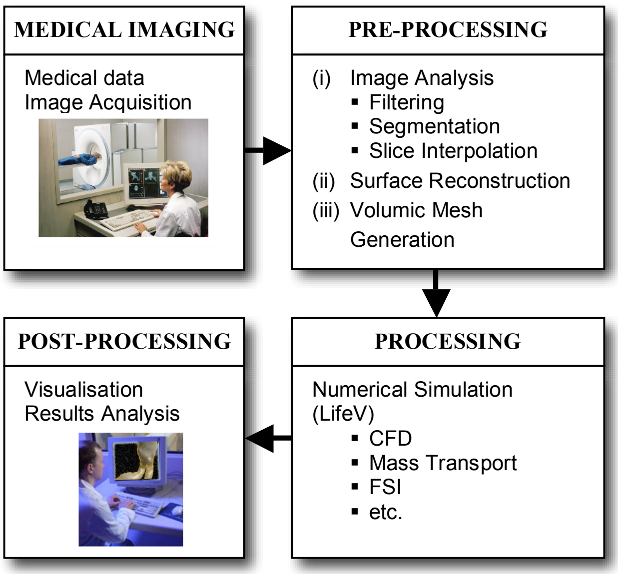

Fig. 1: From medical data and images to numerical simulations.

METHODS: The 3D reconstruction algorithms comprise a set of steps: *(i)* from a stack of medical images (typically in DICOM format), we select a district and after an appropriate filtering, we construct its segmentation using a 3D region growing algorithm and represent it using B-splines for each object of each slide[2]; *(ii)* from the stack of B-splines, we construct the function or surface implicitly defined by an appropriate sampling of the B-splines[3]; *(iii)* from the implicit function, we construct first a surfacic mesh using marching cubes or marching tetrahedra algorithms[4], and finally generate the volumic mesh using standard mesh generator (e.g. GMSH). The last mesh generation step requires many sub-steps to ensure a good mesh quality for the numerical simulations.

RESULTS: From a stack of medical images (one image is shown below on Fig 2 - left), we reconstruct the surface of the aorta in the abdominal area and mesh it as shown on Fig 2 - right.

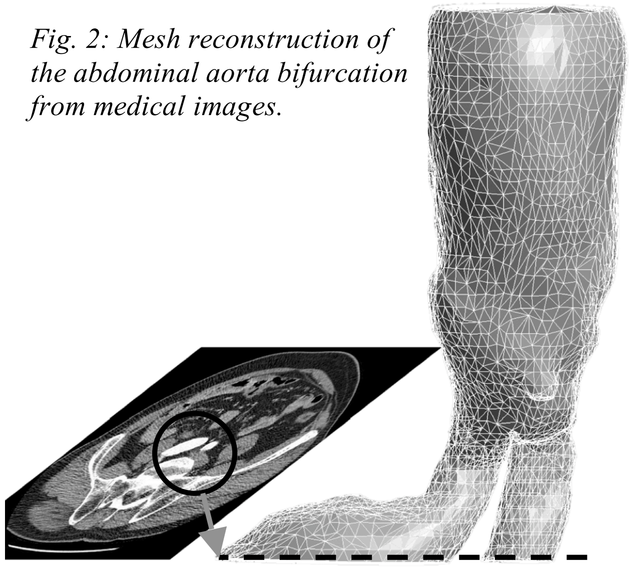

Fig. 2: Mesh reconstruction of the abdominal aorta bifurcation from medical images.

REFERENCES: [1] LifeV project (online 2005) www.lifev.org. [2] R. Adams and L. Bischof (1994) *Seeded Region Growing,* IEEE Trans. on PAMI, **16**(6):641-647. [3] J. C. Carr, R. K. Beatson, J. B. Cherrie, T. J. Mitchell, W. R. Fright, B. C. McCallum, T. R. Evans (2001) *Reconstruction and Representation of 3D Objects with Radial Basis Functions,* ACM SIGGRAPH 2001, Los Angeles, CA, pp. 67-76. [4] V. Rigamontti (online 2005) *Etol Tools User Manual v 0.9.8,* www.lifev.org.

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