Available thesis projects

1) Influence of the aortic root motion in the evolution of the ascending aortic aneurysm.

Topic: image processing and segmentation

The aortic root motion has a direct impact on the mechanical stresses acting on the aorta. This could affect the development of pathologies such as ascending aortic aneurysm. This work aims to investigate if there is a correlation between aortic motion and aneurysm growth rate. Starting with an MRI angiography dataset, the student will have to develop an accurate semi-automatic segmentation method by exploiting VTK, VMTK, ITK libraries, etc. Longitudinal data will be available through which the growth rate in terms of the evolution of the diameter of the aorta over time can be derived. A semi-automatic tracking tool already developed in Python will be used and improved to track the motion of the annulus using cine-MRI images. Finally, statistical analysis will be carried out to identify whether or not there is a correlation between the two previously mentioned parameters.

UTV, Ansys Lyon and CHU Dijon will provide support for the work.

Requirements: good knowledge of Python, basic knowledge on segmentation and image processing.

2) 2D automatic segmentation of cine-MRI images.

Topic: image processing and segmentation

Cine-MRI sequences allow the motion of the aorta to be well-discretized along precise cutting planes. Automatically obtaining the boundary of the aorta from these images means being able to study the kinematics of the vessel at least in a 2D cutting plane.

The student will have to develop a method to automatically segment different sections of the thoracic aorta.

UTV, Ansys Lyon and CHU Dijon will help the student with this work.

Requirements: good knowledge of Python, basic knowledge on segmentation and image processing.

3) Impact of cardiac motion on the calculation of fluid-dynamic biomarkers for the evaluation of the ascending aortic aneurysm.

Topic: numerical high-fidelity simulation

In addition to an effect on the wall, the motion imprinted by the heart on the aorta strongly influences the fluid dynamics of the ascending tract. Fluid biomarkers such as vorticity, wall shear stress (WSS) and time-averaged wall shear stress (TAWSS), and fluid-dynamic parameters such as turbulent kinetic energy (TKE) could vary substantially in fluid-structure simulations by considering or not the heart motion.

The student, for a small dataset of patients, will develop the fluid-structure coupling using Ansys LS-Dyna. It will have to set and optimise through the images patient-specific boundary conditions for both CFD and structural domain. Then, all extracted parameters of interest will be studied and differences in these will be studied.

UTV and Ansys Lyon will support and assist the student in research.

Requirements: good knowledge of structural and fluid-dynamic numerical simulation concepts. A good knowledge of solvers (Ansys Mechanical, Ansys APDL, Ansys Fluent, Ansys LS-Dyna but also Abaqus) is preferred.

4) Real-time CFD simulation of the thoracic aorta using reduced-order models.

Topic: numerical simulation, statistical shape modelling and reduced-order models.

The use of reduced-order models (ROMs) is the key enabling the development of real-time simulation in the biomedical field. For clinical use, there is a need to increasingly reduce computational time and create simple, intuitive, and fast tools that the surgeon himself can use. In this work, the student will first perform segmentations in 3DSlicer. He/she will then use mesh morphing to create iso-topological grids essential for reduced-order models. He will then use all the meshes created to construct a statistical shape model, i.e. a parametric model of the aorta itself controlled by shape coefficients. Various fluid-dynamic simulations will then be performed to create the ROM. The ROM will then be studied and analysed to see its ability to predict fluid-dynamic outputs as model inputs vary.

UTV, Ansys Lyon and CHU Rennes will help the student in this research.

Requirements: good knowledge of Python and of fluid-dynamics solvers.

5) Effect of aortic valve shape and orientation on the fluid dynamics of the ascending aorta.

Topics: numerical simulation, CAD geometric modelling and morphing.

The way in which the outflow from the heart valve impacts the aortic wall is of clinical interest in understanding the evolution of the aneurysm. The variation between tricuspid and bicuspid valves, the presence of calcifications and valvular regurgitation, as well as the orientation of the jet, will affect the propagation of the blood flow in the vessel. The student will use 4D-Flow MRI datasets to optimise the aortic model inlet. By means of mesh morphing, it will be possible to modify the valve, to orient its jet differently until the best match with the images is achieved.

UTV, Ansys Lyon and CHU Dijon will support the research.

Requirements: good knowledge of fluid-dynamics solvers, MRI imaging and CAD tools.

INFORMATION

If interested or with any questions, please do not hesitate to contact us:

- Prof. Marco Evangelos Biancolini: biancolini@uniroma2.it
- Leonardo Geronzi (PhD student): leonardo.geronzi@uniroma2.it
- Antonio Martinez (PhD student): antonio.martinezpascual@ansys.com