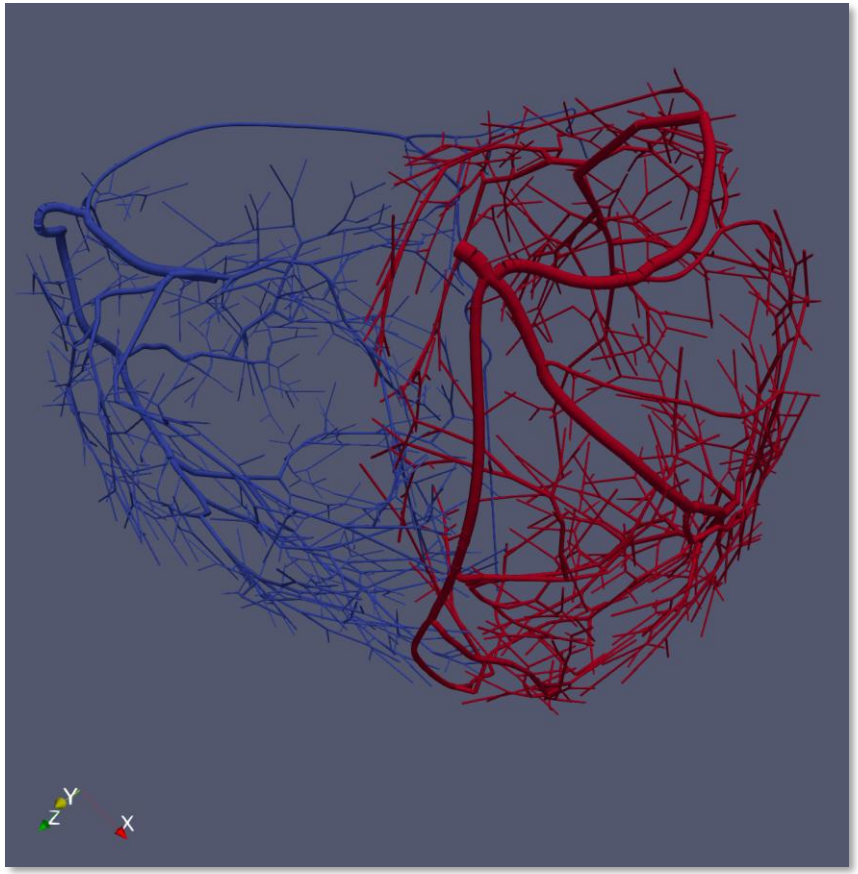
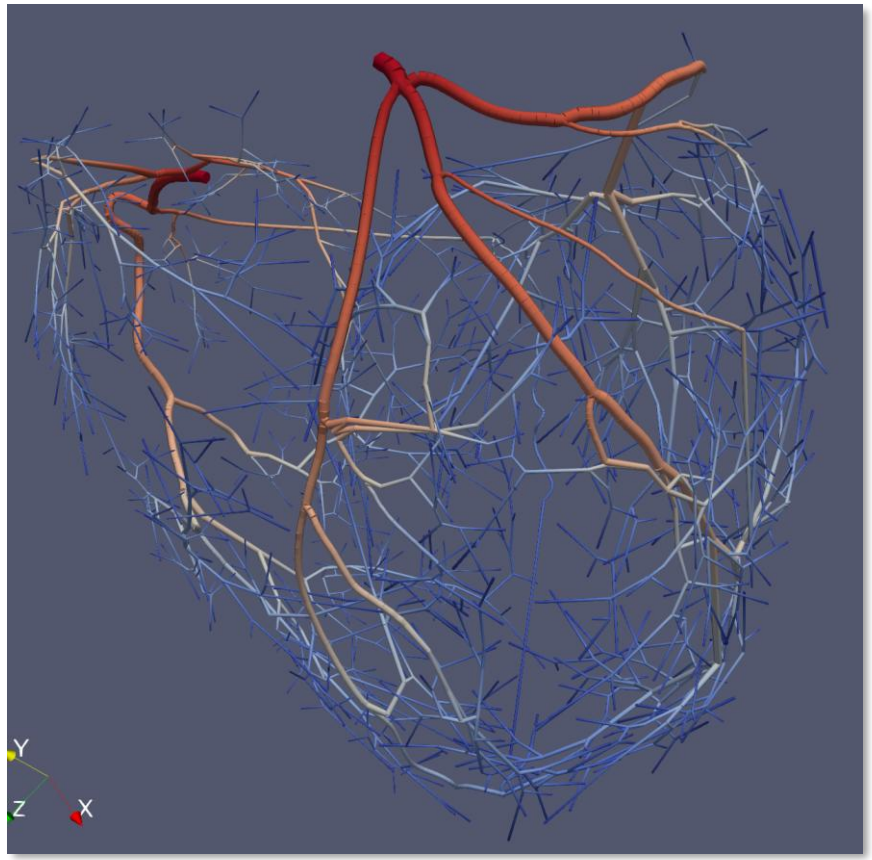
Project 2 – coronary artery bypass

Arterial network modeling

Virtual surgery simulation





Description

Objective:

- Develop a model of the heart arterial circulation and use it to analyze different bypass surgery options for arterial occlusion

Description:

- Heart arterial circulation modeled as a network of bifurcating rigid cylindrical vessels
- Blood flow modeled as steady viscous flow in straight circular cylinders (Poiseuille's flow):
  - Branch resistance: $R = \frac{8\mu L}{\pi r^4}$
  - Blood rheology: viscosity $\mu = 4\ cPoise$, density: $\rho = 1\ g/cm^3$
  - Branch geometry: length L, radius r
  - Branch flow rate: Q
  - Pressure drop along branch: $P_2 - P_1 = \Delta P = R \times Q$
- Boundary conditions:
  - Impose mean aortic pressure at inlets ($P_i = 100\ mmHg$)
  - Impose venous pressure at outlets ($P_v = 10\ mmHg$)

Implementation:

- Read arterial network model: point coordinates, branch (element) connectivity, branch radius, branch tree, lists of inlet & outlet points, branch to occlude, bypass graft options
- Solve: build system of equations (incorporate occlusion, bypass graft, boundary conditions), solve it, calculate flows in each branch, save results for visualization (VTK)
- Visualize: arterial network as a collection of cylinders with corresponding radius and colors representing pressures or flows (Paraview)

Investigate:

- Effects of vessel occlusion (% stenosis)
- Effect of different surgical options
- Increasing / decreasing systemic pressure
- …

Challenges:

- Visualize network points with labels (point nr)
- Introduce another vessel occlusion(s)
- Propose another bypass option(s)
- Create animation of spinning vascular network model
- Calculate total flow exiting from each arterial tree
- Impose outflow resistance boundary conditions