### Abstract

- Vascular disease is the primary cause of death in the US, with nearly one million people die of heart disease, and 17 million are at risk for heart attacks.
- Current hemodynamic assessment techniques yield only the averaged blood flow field with low accuracy and much uncertainty.
- We have two different methods to solve the Navier-Stokes equations using radial basis functions: the Artificial Compressibility Method and the Projection Method. The former introduces an artificial compressibility \( \delta \) into the equations of motion in such a way that the steady state does not depend on \( \delta \). The latter forms an intermediate velocity field and updates it to follow a flow field for the irregular portion of the blood vessel. We assume that the blood flow is incompressible, which means that density is homogeneous in space and time. We also adopt a no-slip boundary condition, expanding its functionality to include a bifurcation, which is one of the above parameters.

### Governing Equations and Assumptions

To obtain a blood flow field, we solve the 3D incompressible Navier-Stokes equations:

\[
\nabla \cdot \mathbf{v} = 0, \quad \rho \left( \frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} \right) = -\nabla p + \mu \nabla^2 \mathbf{v},
\]

with the incompressibility condition \( \nabla \cdot \mathbf{v} = 0 \).

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### RBF Center Generation

We have two methods for generating the nodes for the RBF; we first used an open-source mesh generating program to construct triangular and tetrahedral meshes, and then extracted their vertex points. We also use an algorithm which scatter points randomly within a specified region; this algorithm has an advantage of being significantly faster, as it does not require the construction of a mesh.

Above: We have developed a graphical user interface using Matlab in order to make it easier for users to interact with our code. At this point, the GUI outputs a 3D mesh from a given 2D image, but we’re working on expanding its functionality to include a computed streamline graphic using our hybrid code in its output as well.

### References


Lee, J., and Young, K.: Rapid determination of flow parameters for arbitrary vessel geometries using a database of CFD solutions. Master’s Thesis, Mechanical and Aerospace Department, ECNY University at Buffalo, 2011


### Conclusion

Vascular disease is the primary cause of death in the US and improving its assessment and treatment techniques is of great importance.

We developed a method for center generation and a Navier-Stokes solver using Radial Basis Functions. We are also working on creating a vascular library of a large number of pre-computed 3D CFD solutions with a variety of parameters and developing an interpolation algorithm. This part of the project is still ongoing but so far we have promising results.

Once our goals are reached, the proposed methods that can be used in a clinical time frame by clinicians will significantly improve the hemodynamic assessment process, which will save human lives.