HYPERELASTIC IMMERSED BOUNDARY FINITE ELEMENT MODEL OF A HUMAN HEART

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ABSTRACT. This talk focuses on the construction of a computer model of the human heart which includes the blood, four chambers, valves, and great vessels. Blood is modeled as a viscous, incompressible Newtonian fluid and the solid parts of the heart are assumed to be hyperelastic. Interaction between the fluid and solid is handled by a version of the immersed boundary method where the solid is discretized using Lagrange finite elements, and the blood is approximated on a fixed, locally–refined Cartesian mesh. The numerical approximation follows the work of Griffith and Luo [1], and the implementation uses IBAMR, an open source software framework for simulating fluid/solid interaction with immersed boundary methods [2].

Strain energy densities for the valves and heart myocardium depend on particular fiber vector fields that encode preferential directions in the elastic stress. The fiber vector field for the heart myocardium roughly corresponds to the orientation of the myocytes, and is used in passive mechanics and also in prescribing an active stress, for heart contraction. Fiber vector fields for the valve models are important for ensuring the valves are able to withstand realistic pressure gradients upon closing. Vector fields are created using Poisson interpolation techiques.

Our results include the simulation of a cardiac cycle: loading of the aortic and pulmonary valves, atrial contraction, ventricular contraction, and relaxation. An important component of these results are proper "boundary conditions" on the fluid, which include fluid sources in the atria and realistic traction boundary conditions at the ends of the great vessels.

Keywords: Immersed boundary methods, cardiovascular mechanics

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REFERENCES

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[2] `https://ibamr.github.io`

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