Department of Mathematical Sciences

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Simulation of Fluid-structure Interaction Problems Arising in Hemodynamics

We focus on the interaction of an incompressible fluid and an elastic structure. Two cases are considered: 1. the elastic structure covers part of the fluid boundary and undergoes small displacement and 2. the elastic structure is immersed in the fluid and it features large displacement. For the first case, we propose an Arbitrary Lagrangian-Eulerian (ALE) method based on LieâĂŹs operator splitting. The resulting algorithm is unconditionally stable and weakly coupled: it requires the solution of one fluid subproblem and one structure subproblem, both endowed with Robin type boundary conditions, per time step. This algorithm is applied to blood flow in a healthy straight artery and in a diseased artery with implanted stent. Standard ALE methods fail when the structural displacement is large. Thus, for the second case we propose an extended ALE method that avoids remeshing. The extended ALE approach relies on a variational mesh optimization technique, combined with an additional constraint which is imposed to enforce the alignment of the structure with certain edges of the fluid triangulation without changing connectivity. This method is applied to a 2D benchmark problem modeling valves: a thin elastic 1D leaflet, modeled by an inextensible beam equation, is immersed in a 2D incompressible, viscous fluid driven by the time-dependent inlet and outlet data.

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