A Numerical Technique for Fluid-Structure Interaction Applications

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Fluid-structure interaction (FSI) has important applications in fluid mechanics of biological systems where fluid interacts with the soft surrounding tissue. This study presents a mathematical framework, derived from first principles, to solve an FSI problem that satisfies both momentum and continuity balances and sharply tracks the interfaces between solid and fluid components of the biological system.

The fluid and solid transport equations of mass and momentum are transformed into a moving, body-fitted reference frame. We present the motion of the conformal reference coordinate system using generalized curvilinear coordinates transformations. The proposed model tracks the deformable interfaces between fluid and solid.

The motion equations are coupled and consist of a nonlinear system of partial differential equations (PDEs). The governing PDEs are discretized using the Finite Volumes method with structured meshes. Simultaneous solution approach using Newton-like methods is used, instead of fixed-point iteration methods (SIMPLE algorithm), due to strong coupling and inclusion of non-linear terms in the governing equations. A comparison of the direct solutions approach against fixed-point iteration methods is provided.