An interface-fitted finite element approach for fluid-structure interaction problems with large displacements

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ABSTRACT

Classical moving mesh methods for fluid-structure interaction problems usually suffer from mesh distortion if large displacements of the fluid domain or immersed interfaces are considered.

In this talk, a finite element framework based on moving meshes is presented which aims at resolving these problems. The approach is based on the classical arbitrary Lagrangian-Eulerian (ALE) formulation of the fluid equations, but allows for *temporal* discontinuities of the ALE parametrization. In contrast to traditional ALE based mesh moving/front tracking methods, the deformation of the computational mesh is not directly derived from an extension of the interface displacement. Instead, the mesh is obtained from a variational mesh optimization technique which yields meshes that are aligned with the interface, retain connectivity and can be shown to be of optimal quality. The presented approach allows for large deformations of the moving interface while preserving attractive features of front tracking methods: an accurate description of the interface, and the possibility of designing problem-tailored finite element spaces.

Our methodology is introduced and evaluated in the context of a coupled fluid-structure interaction problem motivated by the interaction of blood flow with the aortic valve. The coupled fluid-structure problem is solved by classical (strongly coupled) partitioned schemes, i.e. Dirichlet-Neumann and Robin-Neumann methods. We assess and benchmark our approach through 2d tests, compare with a standard ALE approach when possible, and comment on the efficiency of the partitioned approaches.

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