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A FINITE ELEMENT METHOD FOR FLUID-STRUCTURE INTERACTIONS WITH LARGE DEFORMATIONS

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In this talk, we present a new finite element method for fluid-structure interaction (FSI) problems with large deformations. Our approach is based on a novel extension of the arbitrary Lagrangian-Eulerian (ALE) formulation of the fluid equations. In many classical FSI approaches based on an ALE formulation, the deformation of the fluid mesh is directly determined by the motion of the structure: "structure" nodes of the fluid mesh are adjusted according to the kinematic boundary condition, and the so defined motion is extended to the interior of the computational domain using an (arbitrary) extension operator. These approaches usually fail once the deformation of the structure and of the fluid mesh become too severe.

To get around this problem, we introduce a new way to construct mesh deformation: while the mesh is still determined in such a way that the fluid mesh is aligned with the structure mesh, as in classical ALE approaches, the new fluid mesh construction uses a fully automated mesh optimization procedure, based on a (non-linear) variational approach. The resulting mesh retains the same topology as the original mesh, while keeping optimal quality even for large deformations, without re-meshing.

The proposed approach is introduced and evaluated in a 2D fluid-1D structure FSI setting, and tested on a benchmark FSI problem simulating heart valves.