A robust stabilised immersed finite element framework for complex fluid-structure interaction

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ABSTRACT

Developing numerical schemes for efficient simulation of complex fluid-structure interaction phenomena has received considerable attention of researchers during the past couple of decades. Despite numerous developments into numerical schemes based on the well-known Arbitrary Lagrangian-Eulerian (ALE) formulation, they have certain inherent disadvantages which limit their applicability to wide range of problems usually encountered in industrial practice. In this work, a robust stabilised immersed framework for the simulation of fluid-structure interaction involving complex geometries is presented. The formulation combines the state-of-the-art techniques in order to efficiently deal with complex geometries and topological changes. Fluid-solid coupling is resolved using a second-order accurate staggered solution scheme, and the solid-solid contact is modelled using Lagrange multipliers. The fluid is modelled using the incompressible Navier-Stokes equations and the solution of the fluid domain is approximated by employing a stabilised formulation on hierarchical b-spline Cartesian grids. Penalty-free unsymmetric Nitsche method is used to impose boundary as well as interface conditions. The adverse effects of small cut cells are avoided by using ghost-penalty operators.

The performance of the numerical scheme is assessed by studying several benchmark examples. The robustness, and the applicability of the numerical scheme to industrially relevant problems, is demonstrated by studying galloping, particulate flows, check valves and turbine models.

References

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