Immersed Boundary Method for the prediction of interactions between fluid and other continuum

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The study of the interactions between fluids and solid structures is relevant to a broad range of application areas (marine engineering for energy harvesting, biological engineering for heart valves, aeronautics for the strength of flaps in aircraft wings, etc). One of the major challenges in predicting this kind of interaction is the creation of adequate computational meshes with realistic complex configurations. Issues arise especially with complex, sharp, moving and deforming boundaries, removing the possibility of automatic creation of a high quality structured mesh.

In this framework, Immersed Boundary Method (IBM) types of method are an efficient alternative to adress these issues. The aim of IBM is to solve a single set of conservation equations for several components (gas, liquids or solids), with non-conforming grid. The presence of the secondary continum is taken into account by modificatying the fluid governing equations. As a result, this type of method lets one handle to handle multi-phase flow or fluid-structure interactions problems, in a single-phase framework. One of the main interests lies in the simplification of the model, in its suitability for use with Cartesian meshes of perfect orthogonal quality, and especially in its compatibility with problems involving very high deformation of the secondary continum, as it is the case for the interaction of fluid with flexible structure.

After an overview of the numerical methods allowing for the prediciton of Fluid-Structure Interaction (FSI), we present recent advances on the penalty based IBM for the simulation of both rigid and flexible deforming solids [2, 3]. The capabilities of the model are demonstrated with a challenging engineering case involving a fast moving slender membrane in a turbulent flow. Finally, we highlight a promising implicit penalization method for predicting the dynamics of a cloud of solid particles, based on the work of Morente et al. [1].

References

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