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An Immersed Boundary Projection Method for Complex Fluid-Structure-Interaction Simulation

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Abstract

Fluid-structure interaction (FSI) problems involving structures with complex outer shape and multiphase flows widely exist in marine engineering and daily life. Such problems challenge numeric methods with the requirement for accuracy, robustness and efficiency. The main stream methods today tend to use either body-conforming meshes or discretely sharp interface methods to handle problems of this category. While maintaining an accurate division of different domains, these methods usually suffer from high computational cost and tedious details due to the relative movement of the interfaces and mesh between time steps. To improve the versatility and efficiency of the solving procedure, we purposed a monolithic immersed boundary projection method (IBPM) based on the continues forcing approach for such kind of problems. Governing equations of the entire system are firstly written into the discrete operator form, which are assembled later into a monolithic system matrix. Then, the monolithic system matrix is decomposed gradually by adopting the nested approximate LU decomposition strategy. Such a procedure decouples the solving of each momentum equations with their related constraints, while preserving the second order temporal accuracy. We have applied this method to the simulation of highly dynamic FSI problems with multiple constraints including a flapping inextensible flag, a mounted windsock and a landing parachute model. All cases have shown good agreements with literature results.