Extension of the immersed boundary method in OpenFOAM to simulate flow-induced motion

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Abstract

Immersed boundary method (IBM) has been developed and improved in the last few decades. Using this numerical method, a wide range of practical problems have been simulated. Among these applications, IBM has shown significant advantages for solving fluid-structure interactions (FSI), especially, for solving FSI problems with complex structures and/or complicated motions. IBM in OpenFOAM was firstly implemented in 2015 using the discrete-forcing direct-imposition method, which provides an alternative approach for the broad scientific community to make use of this numerical method instead of learning a sophisticated in-house IBM code. The implemented IBM in OpenFOAM has been used for simulating the flow around fixed/oscillating immersed cylinders by pioneering researchers. The reported simulation results validated the accuracy of the existing implementation.

In this study, the IBM in OpenFOAM (the version of foam-extend 3.2) is extended to solve the flow-induced motion with deformable immersed boundaries. The original code for controlling the immersed boundary is replaced by a user-defined code. The extension processes demonstrate a way to solve specific problems using the existing code with a few steps of modification. To validate the extension, simulation of anguilliform swimming, a typical FSI, is conducted. The simulation results of the self-propelled swimming model are compared with the corresponding data in the literature. Further, to show the interaction between immersed structures and the interaction between the fluid and the immersed structures, models of anguilliform swimmers swimming in schools are simulated. The hydrodynamics of the multiple bodies swimming models are analyzed and presented. The presented numerical results prove the capability of the extension of the existing code for solving the flow-induced deformable immersed boundary problem.

Keywords: IBM, FSI, OpenFOAM, anguilliform swimming, swimming in schools