An ALE formulation of immersed boundary methods for simulating fluid–structure interaction problems

†*Wen-Quan Wang

Department of Engineering Mechanics, Kunming University of Science and Technology, Kunming 650500, China

*Presenting author: wqwangkm@126.com
†Corresponding author: wqwangkm@126.com

Abstract

An immersed boundary method (IBM) in a moving frame is proposed in this paper to study fluid–structure interaction problems. This solver includes the predictor and corrector steps. In the predictor step, the intermediate flow field is predicted on a moving Cartesian grid by Arbitrary Lagrangian–Eulerian(ALE) methods. In the corrector step, velocity correction is made by the implicit immersed boundary method to accurately satisfy the no-slip boundary condition. The motion of rigid body is obtained by solving the governing ordinary differential equations using the forth-order Runge–Kutta method. By enforcing the speed of the Cartesian grid the same as the translational velocity of the rigid body, the present solver is able to study a freely large movement object in a large flow domain. It not only extends the applicability of fixed grid-based solver but also considerably reduces the number of grid points and computational efforts. In addition, the re-meshing process, which is commonly used in the conventional ALE for Body-fitted or moving mesh approaches, is avoided. Several benchmarks, including an actively moving cylinder, freely falling quadrilateral with finite aspect ratios and a semi-active movement of a flapping foil, are studied to examine the reliability of the proposed solver. The obtained results compare well with theoretical and/or experimental data, which successfully demonstrate the capability of the proposed solver for fluid–structure interaction problems.

Keywords: Immersed boundary method; the implicit velocity correction method; Arbitrary Lagrangian Eulerian method; Fluid-structure interaction; Flapping foil