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ON THE CONTROL OF SPURIOUS FORCE OSCILLATIONS FOR MOVING BODY PROBLEMS USING AN IMMERSED BOUNDARY METHOD

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We present a Direct Forcing (DF) approach for simulations of flows over moving bodies, on a Cartesian grid, capable of reducing the amplitude of the force oscillations, by using a two-phase predicted velocity. We have identified the primary source of these oscillations as the temporal discontinuity of the forcing term across the fluid-solid interface, concerning mainly the dead cells.

We use a two step prediction-correction Finite Volume method, where the DF applies in the two steps. A penalized version is presented in [1]. The original DF approach consists in forcing the predicted velocity to the solid velocity when the velocity point comes into the solid domain. Therefore the forcing term is highly discontinuous in time for dead cells leading to the famous spurious force oscillations. In the proposed DF approach, the fluid component of the two-phase average velocity is chosen such a way that the magnitude of the forcing term tends to zero with the volumic fraction of solid in the considered control volume. By modifying the definition of the fluid component, it is possible to change the order of approximation of the method. A first order and a second order version of the method are presented. This method is very easy to implement, effective and improve the numerical precision by comparison with the original DF approach, see Fig. 1. The same idea is applied to the projection step, imposing the rigidity constraint to the solid.

To demonstrate the effectiveness of the present DF forcing approach in comparison with the original one, we simulate two classic moving-body problems from the literature by varying both the grid spacing and the computational time step. The force oscillations are almost entirely suppressed for the first test case [3], where we consider an oscillating cylinder in a fluid at rest, see Fig. 1. Concerning the second test case [4], dealing with an oscillating cylinder in a cross flow, the present DF approach decreases the amplitude of the oscillations by almost one order of magnitude. The results obtained with the present approach are similar to those obtained with much more complicated method [2], [3], [5]. Consequently, by choosing carefully the grid spacing and the time step it is possible to control and manage the magnitude of the force oscillations, leading possible to simulate full fluid structure interaction problems such as flow induced vibration.

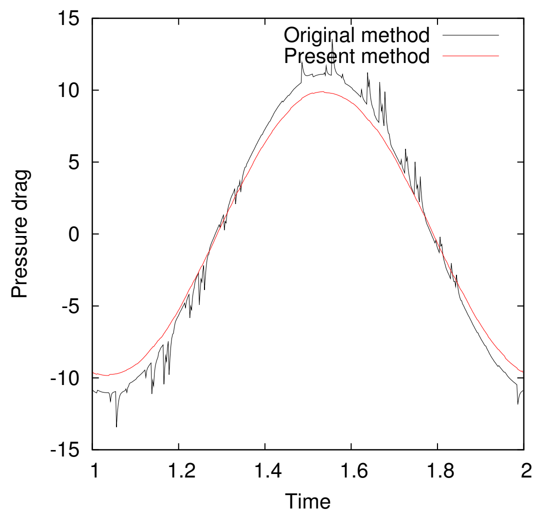

Figure 1: Time evolution of the pressure drag for an oscillating cylinder, test case number 1, using the original method and the present method, both with the first order version.

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