Acceleration of Fluid-Structure Interaction Procedures by Anticipatory Coupling

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ABSTRACT

Simulating the hydrodynamics of floating structures using a two-way partitioned coupling poses a major challenge when the coupling between the fluid and the structure is strong. The incompressibility of the fluid plays an important role, and leads to strong coupling when the ratio of so-called *added mass* to structural mass is considerate. Existing fluid-structure interaction procedures become less efficient in such cases, and can even become unstable [1]. This paper proposes a coupling method that deals with the added-mass effect by anticipation, and remains stable and efficient at all times.

The structural model consists of a rigid body with elastic mooring lines, and the fluid is modelled by the Navier-Stokes equations with a volume-of-fluid method for the free surface [2, 3]. Instead of imposing the structure displacement to the fluid as usual, a combination of pressure and displacement is prescribed to the fluid, that approximates the dynamical behaviour of the body. Through this modified boundary condition, the flow can anticipate the structural motions. This anticipatory coupling method increases the numerical efficiency, while the results are—by design—the same as in the usual formulation.

The effectiveness of the new method was tested on realistic applications such as the impact of a lifeboat in a wave, and the excitation of an offshore platform interacting with waves. These cases have a high and moderate added-mass ratio, respectively. With anticipatory coupling, the costs were reduced by a factor of 10 and 3 in terms of computational operations with respect to the usual formulation.

References

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