Efficient fluid-structure simulations in hydrodynamic appplications involving high Reynolds number and free surface.

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ABSTRACT

Fluid Structure Interaction (FSI) problems are commonly encountered in naval architecture, where the configurations generally involve both high Reynolds number and free-surface. From the fluid side, two different numerical methodologies to deal with FSI can be distinguished: numerical methods which extend classical Navier-Stokes solvers based on body-fitted meshes through an Arbitrary Lagrangian Eulerian (ALE) approach and new paradigms based on Immersed Boundary (IB, also called Embedded Boundary) where the fluid-structure interface is no more a boundary of the mesh but captured through an implicit surface, generally described by a level-set method. Even if the versatility of IB is an advantage, as it has no limitation in terms of structural deformation and body contact, body-fitted mesh approaches remain up to now the most accurate solution for high Reynolds number configurations where the capture of the turbulent boundary layer and the accurate prediction of viscous fluid forces are crucial. To conserve the high-Reynolds performance of ALE while approaching the versatility of IB, we propose here a numerical approach which pushes the limits of the ALE formulation, through the combined use of the overset approach and adaptive grid refinement (AGR) [1], developed in the Finite-Volume solver ISIS-CFD: overset approach with deformable external boundaries allows to handle large body deformations while keeping a high mesh quality around both the deformable body and the free surface. AGR ensures numerical accuracy by refining the mesh not only to adapt the grid density to the flow solution (for example the free surface) but also to ensure mesh size continuity over the moving overlapping boundary. The FSI coupling algorithm, based on an efficient two-ways partitioned approach leading at convergence to the monolithic solution, will also be presented [2]. In particular, the speed-up due to the hybrid use of the classical mesh deformation techniques and the transpiration method [3] will be shown.

REFERENCES

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