Capturing efficiently the fluid/solid interface of a large collection of interacting objects immersed in a fluid

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Mots-clés : fluid/structure interaction, level set, multiple objects, collision model.

We propose a numerical model to efficiently capture an arbitrary number of fluid/solid or fluid/fluid interfaces, with interaction forces, in a level set framework. The proposed algorithm is inspired by the MGDM segmentation method introduced in [1]. The fluid/structure domain is decomposed into several regions: one for each immersed object, and one for the surrounding fluid.

A configuration of these objects is described by three label functions giving the object number to which the point x belongs, a distance from x to the closest object, and another to the second closest object. Only one level set function captures the union of all interfaces and is transported with the fluid velocity. A local fast marching method is performed at each time step to evolve the label and distance functions.

Within this framework, the numerical treatment of contacts between the structures is achieved by a short range repulsive force which depends on the distance to the closest interface. The key feature of the method is that it only requires five functions to track any number of objects and to handle collisions, which lowers the complexity in the evaluation of the repulsion force.

The proposed numerical model was validated through the simulation of a dense suspension of rigid bodies immersed in an incompressible fluid. A penalisation method is used for the fluid/solid coupling [2]. Results are compared to the collision model introduced in [4] where N level set functions were used to capture N fluid/solid interfaces.

The numerical tests show that our method substantially reduces the computational cost when dealing with a large number of structures. A generalization to elastic objects is under development for a future publication [3].

Références

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