

Immersed method with metric based anisotropic mesh adaptation for Multiphase Flow and Fluid Solid Interaction

T. Coupez¹, N. Nemer¹ and E. Hachem¹

¹ MinesParis CEMEF, CS10207 - F-06904 Sophia Antipolis cedex, France
Thierry.Coupez@minesparis.psl.eu
Rami.Nemer@minesparis.psl.eu
Elie.Hachem@minesparis.psl.eu
<https://www.cemef.minesparis.psl.eu/>

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A wider use of numerical simulation is depending on meshing and adaptive meshing capabilities when complex geometry, multi-domain, moving interface and multiphase flow are involved. In order to overcome the lack of flexibility of the common body fitted method, the alternative we proposed, is based on an implicit representation of the interfaces by a local distance function using a hyperbolic tangent filter. It remains an immersed method but combined with anisotropic mesh adaptation providing a unique mesh on which a monolithic formulation can be written for various multiphase applications. Moreover, the geometries are interpolated and shown to contribute to the numerical error, and we propose a way to embed it in the a posteriori error estimator. This approach favours the full usage of anisotropic adaptive meshing techniques providing an optimal capture of the interfaces within the volume mesh, whatever is the complexity of the involved geometries. The multiphase flow solver with unstructured meshes with possibly highly anisotropic elements (however solution aligned) enters in the framework of continuous stabilized finite element method (here a residual based stabilisation) that can afford with anisotropic meshing with high aspect ratio elements in a quasi-optimal way. Indeed, the stabilisation parameter is shown to be controlled by the minimal width of the element, which guarantee the lowest added diffusion. The interface condition transfer is enforced straightforward by the continuity of the mesh, the jump in stress is controlled by a steep gradient both for fluid/fluid and or fluid/fluid/structure interaction.

Several questions are arising from this formulation. About the error estimator which is based on a true estimation for Navier Stokes using both the velocity and the pressure and augmented by the error on the trace operator accounting for the interpolation error of geometries (may be one of be the first attempt to plug the geometry discretisation in the estimation error). Other points are about the apparent or not over continuity of the stress, the added mass problem, the surface tension calculation for more than two phases (notion of contact angle in immersed method). Examples with industrial applications will be proposed in fluid structure interaction, liquid air solid interaction with surface tension (three phase capillarity and wettability) for a coating application (the drag-out problem) and the floating body problem (3 phases problem with gravity) where the added mass problem need to be solved consistently to get stable and accurate solutions.

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