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Implicit interfaces and anisotropic mesh adaptation for fluid structure interactions

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We propose a full Eulerian framework for solving fluid-structure interaction (FSI) problems based on a unified formulation in which the fluid-structure interactions are modelled by introducing an extra stress in the momentum equation. The obtained three-field velocity, pressure and stress system is solved using a stabilized finite element method. The key feature of this unified formulation is the ability to describe different kind of interactions and to solve different type of flows: laminar or turbulent flows without the need of turbulence modelling. Moreover, all the interfaces are implicitly defined by a level set function and the discontinuities are regularized using a hyperbolic tangent function with a given thickness controlled by dynamic anisotropic mesh adaptation.

We will show that anisotropic mesh adaptation enables to solve really new problems. The basic ingredient of the proposed technique is the interpolation error metric framework which gains nowadays strong theoretical background [1,2]. It relies on the solver capability to handle such meshes. We want to show in this presentation that the VMS approach is among the best method to deal with anisotropic finite elements [3]. However, it requires tuning of the stabilization coefficients in both the convective and diffusive terms to take into account highly stretched elements with an anisotropic ratio of the order of O(1 : 1000). Indeed, based on our numerical experiments, the directions of the velocity clearly provides the element size needed in the convection terms while a bubble condensation technique gives rise to a proper coefficient for the diffusion term [4]. The adaptation algorithm is applied to several applications such as multiphase flows with high density ratios, high Reynolds number showing to be extremely efficient for problems with boundary layers and flow detachments.

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