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A stabilized XFEM based fixed-grid approach for fluids with moving boundaries

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ABSTRACT

XFEM based fixed-grid approaches represent very promising approaches when dealing with moving boundaries or more complex fluid-structure interaction (FSI) applications involving large deformations of the structure. Describing the entire fluid domain by a fixed-grid Eulerian formulation using cut elements allows for large and complex changes of the physical fluid domain without fluid mesh distortion and eventually, remeshing of the fluid domain.

Hereby, high demands are made on approximation quality, stability and accuracy of the fixed-grid formulation, particularly with regard to moving boundaries or interfaces in time. Since the mesh is not fitted to the domain, boundary and coupling conditions are imposed weakly using a stabilized Nitsche type approach or stress based Lagrange multipliers [1][2]. In case of arbitrary cut elements these methods can loose stability and control of the non-physical degrees of freedom outside the physical domain. To retain accuracy in imposing boundary conditions without blowing up the condition number of the linear system Ghost Penalty stabilization approaches recover coercivity independent of the cut configuration [2]. In a similar manner, inf-sup instabilities are compensated by a gradient-penalty based edge-oriented fluid stabilization. These techniques have been extended to the incompressible Navier-Stokes equations on cut elements to obtain a robust, stable and accurate approach and an improvement of the system conditioning without element manipulation or blocking strategies of degrees of freedom.

Hence, in this talk we propose a fully stabilized XFEM-based formulation for 2D and 3D Navier-Stokes equations on non-boundary-fitted fixed grids. Results from numerical examples of fluid problems with structural interfaces will be shown and discussed in context of stability and accuracy.

REFERENCES

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