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NITSCHE-BASED FINITE ELEMENT METHODS FOR CUT AND COMPOSITE MESHES WITH APPLICATIONS TO FLUID AND FLUID-STRUCTURE INTERACTION PROBLEMS

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ABSTRACT

Multi-domain and multi-physics problems with moving interfaces and parameter studies with changing geometric domains can be severely limited by the use of conforming meshes when complex geometries in three spatial dimensions are involved. To overcome these limitations, several fixed-grid methods based on XFEM, unfitted discontinuous Galerkin methods and related approaches have been investigated and shown promising results in recent years.

In this work, we present Nitsche-based formulations for a class of stabilized finite element methods for fluid dynamic related problem posed on fictitious [1] and overlapping domains [2]. First, we briefly review how sophisticated algorithms and data structures from the field of computational geometry can be employed to efficiently implement schemes on overlapping meshes or non-matching interfaces [3]. Then we address various ways to make the formulations robust and to avoid ill-conditioned linear algebra systems by adding certain so-called ghost-penalties in the vicinity of the boundary and interface. As a consequence, the resulting methods are inf-sup stable and optimal order a priori error estimates can be established. Moreover, the condition number of the resulting stiffness matrix is shown to be bounded independently of the location of the boundary and interface. Finally, we present numerical examples of fluid dynamic and fluid-structure interaction problems in three spatial dimensions confirming the theoretical results and illustrating the applicability of the methods to complex 3D geometries.

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