An Adaptive Mesh Refinement Concept for Viscous Fluid-Structure Computations Using Eulerian Vertex-Based Finite Volume Methods

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ABSTRACT

Embedded Boundary Methods (EBMs) [1] for the solution of Computational Fluid Dynamics (CFD) and Fluid-Structure Interaction (FSI) problems are typically formulated in the Eulerian setting, which makes them more attractive than Chimera and Arbitrary Lagrangian-Eulerian methods when the structure undergoes large structural motions and/or deformations. In the presence of viscous flows however, they necessitate Adaptive Mesh Refinement (AMR) because unlike Chimera and ALE methods, they do not track boundary layers [2]. In general, AMR gives rise to non-conforming mesh configurations that can complicate the semi-discretization process. This is the case when this process is carried out using the popular *vertex-based* finite volume method and *dual* cells. Perhaps for this reason, most of the literature on AMR in the context of EBMs and the FV method has focused so far on *cell-centered* schemes, where the treatment of non-conforming mesh configurations is straightforward [1]. Specifically, most if not all local refinement strategies developed in this context generate "hanging" nodes in the refined mesh that can be easily dealt with using cell-centered but not vertex-based methods. In the latter case, flux assembly after a mesh refinement step becomes a problematic issue, due to presence of dual cells. This talk proposes a simple approach for resolving this issue by appropriately managing the construction of dual cells past each refinement step. The talk will recall the motivations for EBMs and vertex-based FV methods, explain the aforementioned AMR issue that arises in their context, present a method for resolving it, and illustrate this method with the application of the EBM known as FIVER (Finite Volume method with Exact two-phase Riemann solvers) [3, 4] to various examples including the prediction of the aerodynamic performance of a Formula 1 car.

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