An Innovative CFD Tool to Solve the Euler Equations Within the Finite Volume ALE Framework Over Adaptive Grids

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Abstract

Despite the dramatically progresses in numerical techniques and computer performances, the simulation of geometrically complex and three-dimensional moving-body problems still represents a challenge for the CFD community. Two main difficulties arise when performing such numerical simulations: the presence of phenomena characterized by different spatial scales and the arbitrary large movements of solid boundaries. Mesh adaptation techniques are usually exploited to effectively deal with these two tasks.

In this work, a novel approach has been developed to solve the finite volume discretization of the Euler equations within the Arbitrary-Lagrangian-Eulerian (ALE) framework even in presence of topology modifications, like edge swapping, node insertion and deletion. Thanks to a sequence of three fictitious steps, these mesh modifications are interpreted as continuous deformations of the finite volumes that compose the mesh and the volume changes are computed so that the Discrete Geometric Conservation Law (DGCL) is automatically satisfied. The solution on the new grid is therefore obtained in a conservative manner by including additional, fictitious ALE terms [1,2]. Since any explicit interpolation of the solution is avoided, the conservative and stability properties of the scheme are preserved.

These strategy has been implemented in the innovative CFD tool obtained by linking the flow solver FlowMesh, currently under development at Department of Aerospace Science and Technology of Politecnico di Milano, to the automatic tetrahedral remesher Mmg3d, developed by Cécile Dobrzynski at INRIA Bordeaux [3]. Three-dimensional unsteady simulations of infinite- and finite-span wing are presented to assess the correctness of the proposed approach.

References

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