An Arbitrary Lagrangian Eulerian Formulation for Isogeometric Discontinuous Galerkin Schemes

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ABSTRACT

In this work the Isogeometric Discontinuous Galerkin [1] method for solving hyperbolic conservation laws is extended to time dependent geometries using an Arbitrary Lagrangian Eulerian (ALE) approach. Among the various ALE formulations that have been proposed in the context of Discontinuous Galerkin schemes, we consider the one presented in [2], which ensures the preservation of constant solutions without the need of any additional equation. The Isogeometric paradigm allows us to easily handle arbitrary high-order mesh deformations by simply moving the control point net, obtaining smooth displacements thanks to the regularity properties of NURBS.

The proposed approach is validated using analytic test cases for the 2D advection and compressible Euler equations, optimal convergence rates are shown from 2^{nd} up to 6^{th} order of accuracy, without significant loss of precision with respect to fixed grids. Next, the laminar viscous flow around a 2D oscillating cylinder [3] is investigated using NURBS patches, so that the geometry can be exactly represented even with very coarse discretizations. Different mesh movement techniques are compared, the simulation is performed using both a rigidly moving domain and a smooth displacement field. We show that the use of a high-order deformation does not impact the time evolution of the aerodynamic coefficients.

We also propose a strategy to deal with non-conforming grids in the case of non-linear mesh movement laws, allowing the use of a quadtree-like local mesh refinement in the ALE framework. This methodology is exploited for the simulation of a pitching NACA 0012 airfoil, where the Isogeometric approach is compared with classical linear grids in order to assess the gain of using a high-order geometric representation.

REFERENCES

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