High-Order Isogeometric Methods for Compressible Flows. Part 1: Theoretical Foundations and Early Applications

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ABSTRACT

In this talk, we present the theoretical background, an outline of its practical implementation and early simulation results of the application of the Isogeometric Analysis framework (IGA) to compressible inviscid flows governed by the equations of gas dynamics.

Computer-aided design (CAD) and finite element analysis (FEA) tools are nowadays widely used in many industrial design processes. In the simplest setting IGA brings those worlds closer together by using the same mathematical formalism (e.g., B-Spline basis functions) for representing the geometry in the CAD tool and for approximating the numerical solution to PDE-problems [2].

IGA was been applied very successfully to many problem classes like linear elasticity, heat transfer and incompressible flow problems but its application to compressible flows is very rare [4, 1]. However, its ability to accurately represent complex geometries used in industrial applications makes IGA a suitable tool for the analysis of compressible flow problems that require the accurate resolution of boundary layers. The inviscid flow solver presented in this talk, is an indispensable step on the way to developing a compressible solver for complex viscous industrial flows.

It is well known that the standard Galerkin finite element method and its isogeometric counterpart suffer from spurious oscillatory behaviour in the presence of shocks and steep solution gradients. As a remedy, the algebraic flux correction paradigm [3] is generalized to B-Spline basis functions so as to suppress the creation of oscillations and occurrence of non-physical values in the solution.

This work provides early simulation results and conclusions necessary for further development and investigation of IGA-based solvers for compressible flow problems.

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