High-Order Isogeometric Methods for Compressible Flows. Part 2: Towards Efficient Implementations on HPC Platforms

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ABSTRACT

High-order CFD methods have become popular over the last two decades due to their ability to provide higher accuracy at lower costs compared to their low-order counterparts and their greater FLOPs/byte ratio making them attractive for developing scalable codes on HPC hardware.

In this talk, we propose a novel approach to design high-order Galerkin methods for compressible flows [3] based on the Isogeometric Analysis (IgA) framework [2]. It builds on the generalization of the algebraic flux correction paradigm [5] to higher-order B-Spline basis functions and adopts strong stability preserving explicit Runge-Kutta time-integration schemes for advancing the solution forward in time. The presented approach is embedded into a multi-patch discontinuous Galerkin formulation to enable the simulation of more complex geometries that cannot be represented by a single IgA-patch or suggest the use of multiple patches to vary the order of B-Spline bases locally.

Our implementation makes use of advanced spline technologies realised in the open-source G+Smo library [4] such as THB-Splines, which enable locally adaptive refinement of basis functions (similar to h-adaptivity in FEM) for improving the resolution of both the computational geometry and the numerical approximation of the flow field. We furthermore discuss practical aspects of our implementation such as the efficient formation of fluxes and flux-Jacobians from precomputed coefficient matrices and smart and fast expression templates [1]. The suggested meta-programming approach is particularly suitable for heterogeneous HPC platforms since it allows to generate hardware-optimized compute kernels from the same high-level C++ code.

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