Preparing the path for the efficient simulation of turbulent compressible industrial flows with robust collocated DG-RK solvers

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Discontinuous Galerkin (DG) methods are usually infamous for being computationally complex and having robustness issues. However, during the last few years, thanks to the development of entropy stable spatial schemes of any order with the summation-by-parts property, robust and efficient entropy stable nodal versions of the DG schemes have been proposed. However, stability constraints usually limit severely the time step size that can be used to integrate in time the system of ordinary differential equations arising from the spatial discretization with high-order algorithms. These constraints are drastically exacerbated by the i) the mesh element aspect-ratio used to resolve "economically" turbulent flows, and ii) the poor quality of the mesh element for complex geometries.

We present a detailed analysis of the performance of relaxation Runge–Kutta schemes and Runge–Kutta time integration schemes optimized for the spectrum of the semidiscretization of the Euler equations in this paper. The CFL condition or an embedded Runge–Kutta pair are used to combine both time-stepping families with time step adaptivity. When compared to standard and widely used methods for complex industrially relevant turbulent test cases, the new optimized schemes demonstrated an overall speedup of more than 35

Finally, we present a detailed analysis of the performance of the in-house KAUST SSDC framework on the Amazon web service (AWS) cloud computing. The industry is very interested in using this on-demand technology for performing engineering simulations. Thus, testing and assessing the performance of a prototype of next-generation compressible CFD solvers, such as SSDC, is relevant. The results indicate that SSDC scales quite well on the most recent and exotic computing architectures available on the AWS cloud computing platform.

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