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Fully Discrete Explicit Entropy-Stable Flux Reconstructions Schemes for Nonlinear Scalar Conservation Laws

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ABSTRACT

Entropy-stable spatial discretizations are applied in computational aerodynamics problems because they ensure stable computation for compressible flows with discontinuous solutions, without the need for additional filters. Recently, research effort has turned toward entropy stability in time-stepping methods, which extend the stability properties of entropy-stable spatial semidiscretizations to any solution time in unsteady problems. This work implements explicit higher-order time-stepping methods which guarantee entropy stability at all time steps. Ketcheson's relaxation Runge-Kutta (RRK) method will be used, wherein entropy stability is enforced by modifying each time-step size in Runge-Kutta methods. The RRK method adds only one algebraic equation; therefore, the more robust solution technique incurs minimally increased computational cost. We use a discontinuous Galerkin framework with a flux reconstruction method for spatial entropy stability. Our combination of spatial and temporal entropy stability methods is novel in published literature. The combination is higher order and entropy-stable in both space and time.

We discuss the solution behaviour and computational cost by solving model canonical problems. We will demonstrate the properties of the method using the one-dimensional Burgers' equation. The scheme is currently being extended for the Navier-Stokes equations. The results demonstrate entropy stability over a long solution time. Our results show that the RRK ensures stability in unsteady problems with discontinuous solutions.

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