Current Status of High-order Residual Distribution Schemes for Non-linear Hyperbolic Problems

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In the framework of hyperbolic problems, methods allowing for high-order of accuracy are of great interest. Among those strategies, very popular choices are given by the ENO and WENO approaches, which can mostly be found within finite volume and discontinuous Galerkin methods, applied on different types of models and applications. Approaches based on globally continuous approximations of solutions, such as finite elements, have not gained yet in popularity, due to the misplaced belief that they possibly might not allow for conservation at a local level[1].
An extremely interesting class of finite element type methods is given by Residual Distributions, first conceptually introduced by P.L. Roe in 1981 and which count several contributions thanks to Deconinck's, as well as Ricchiuto's, research groups. While for this class of schemes high-order of accuracy had been first achieved only in space for steady problems, more recently, a novel strategy has been designed to guarantee high-order of accuracy both in space and time for unsteady modelling equations.
As such, we present our most recent major contributions within this context, along our results obtained on a variety of different unsteady non-linear hyperbolic problems, ranging from standard fluid mechanics to multiphase flows. The ultimate goal is to show, that our method allows for high-order of accuracy in smooth regions of the flow, while ensuring robustness and a non-oscillatory behaviour in the regions of steep gradients, in particular across shocks.

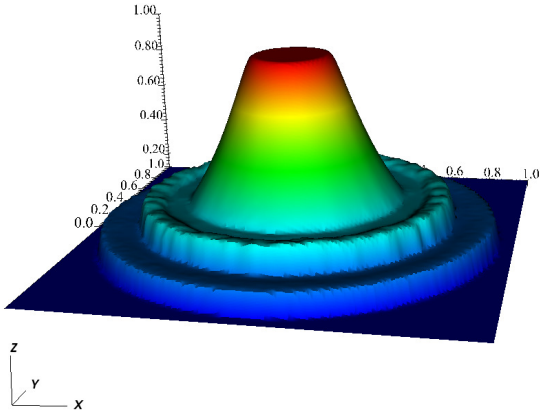

Figure 1: 2D Sod problem - Density for a 3rd order of accuracy scheme on a 120 × 120 grid.

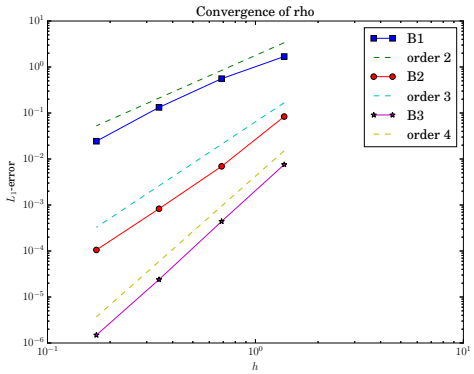

Figure 2: 2D Sationary Vortex convergence study for the density for different order of accuracy schemes.

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[1]Nowadays, one can count different contributions showing that finite element schemes can possibly be reinterpreted in flux form, with explicitly computable non-standard flux functions.