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Towards rigorous error control for numerical methods for hyperbolic problems

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Mesh adaptive algorithms based on rigorous computable/a posteriori error bounds are now established tools for variational (finite element type) methods for elliptic PDEs in the last 30 years or so. More recently, during the last 15 years or so, a posteriori bounds for various numerical methods for parabolic problems has been successfully addressed and is still an active area of research with rich output. Still in the context of numerical methods for first order hyperbolic PDEs, the lack of regularity of the PDE solution, leads to extreme difficulties in developing a respective rigorous theory of a posteriori error bounds. For second order hyperbolic PDEs, a key challenge is the derivation of rigorous a posteriori bounds for explicit time-stepping schemes, used in their temporal discretisation. I will discuss the challenges in proving such a posteriori bounds for first and second order hyperbolic problems. Next, I will present some new a posteriori bounds for two popular numerical methods for hyperbolic problems: the Runge-Kutta discontinuous Galerkin (RKDG) method for first order hyperbolic problems and the leap-frog method for wave equations. To highlight the links between the treatment of numerical methods for first order hyperbolic equation and respective elliptic singular perturbations of such, I also discuss a new a posteriori bound for the discontinuous Galerkin method applied to an 1D convection-diffusion problem. The theoretical developments will be furnished with a number of numerical experiments

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