A Space-time Adaptive Discontinuous Galerkin Schemes for Essential Hyperbolic Problems

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In this paper we describe a discontinuous Galerkin schemes for unsteady fluid flow, which allows adaptivity in the space-time domain. The scheme is based on a predictor-corrector formulation, which is described in [1] in detail. The predictor takes into account the time evolution of the data in the grid cell within a time step and thus establishes a local continuous space-time approximate solution within the whole space-time grid cell. This results in the property that values can be calculated at every point of a space-time grid cell interface, which then allows a time-consistent local time-stepping in a natural way. Every grid cell can be advanced in time with an own time step, which is the basis for the local space-time refinement. The considered discontinuous Galerkin scheme allows polymorphic grid cells with hanging nodes, a local order of accuracy by a spatial basis enrichment and adaption of the time approximation and refinement or coarsening of the grid.
We describe in this talk all the building blocks and our criterions to control space-time adaptivity. Beside the measure of the local resolution we also take into account a guarantee that visualized results have a good quality. Visualizations of piecewise continuous approximations with jumps at the grid cell interfaces introduce often artifacts in under-resolved regions; e.g., one criterion is the smoothness of the path lines of the vortex cores. We will show a number of numerical results for flow problems.

[1] G. Gassner, F. Lörcher, C.-D. Munz, J. S. Hesthaven, Polymorphic nodal elements and their application in discontinuous Galerkin methods, J. Comput. Phys. 228 (2009), 1573-1590