16th International Conference on Finite Elements in Flow Problems (FEF 2011)
W.A. Wall and V. Gravemeier (Eds)
Munich, Germany, March 23–25, 2011

DG Methods for Aerodynamic Flows: Higher Order, Error Estimation and Adaptive Mesh Refinement

Ralf Hartmann

German Aerospace Center (DLR), Institute of Aerodynamics and Flow Technology
Lilienthalplatz 7, 38108 Braunschweig, Germany
Ralf.Hartmann@dlr.de

Discontinuous Galerkin (DG) methods allow higher-order flow solutions on unstructured or locally refined meshes by increasing the polynomial degree and using curved instead of straight-sided elements. Aerodynamic force coefficients like the drag, lift and moment coefficients are the most important quantities in aerodynamic flow simulations. In addition to the exact approximation of these quantities it is of increasing importance, in particular in the field of uncertainty quantification, to estimate the error in the computed quantities. An estimate of the error in computed force coefficients includes primal residuals multiplied by the solution to an adjoint problem related to the force coefficients. This estimate can be decomposed into a sum of local adjoint-based indicators which can be employed to drive a goal-oriented adaptive mesh refinement algorithm specifically tailored to the accurate and efficient approximation of the aerodynamic force coefficients [1,4]. Residual-based indicators include the element, face and boundary residuals of the discrete flow solution. They do not depend on an adjoint solution or a specific target quantity. Thus, they target at resolving the overall flow solution. Numerical experiments show that the residual-based mesh refinement is particularly well suited for resolving flow features like vortices [4].

In this talk we consider the higher-order and adaptive DG methods for the RANS-$k\omega$ equations. Their implementation in the PADGE code [2] will be applied to aerodynamic test cases considered in the EU projects ADIGMA [3] and IDIHOM.

References

[1] R. Hartmann, J. Held, T. Leicht. Adjoint-based error estimation and adaptive mesh refinement for the RANS and k-ω turbulence model equations. J. Comput. Phys., 2010. In press.
[2] R. Hartmann, J. Held, T. Leicht, F. Prill. Discontinuous Galerkin methods for computational aerodynamics – 3D adaptive flow simulation with the DLR PADGE code. Aerosp. Sci. Technol., 14 (2010) 512–519.
[3] N. Kroll, H. Bieler, H. Deconinck, V. Couallier, H. van der Ven, K. Sorensen, editors. ADIGMA - A European Initiative on the Development of Adaptive Higher-Order Variational Methods for Aerospace Applications, Notes on Numerical Fluid Mechanics and Multidisciplinary Design, vol. 113, Springer (2010).
[4] T. Leicht, R. Hartmann. Error estimation and anisotropic mesh refinement for 3d laminar aerodynamic flow simulations. J. Comput. Phys., 229 (2010) 7344–7360.