Adjoint-based error estimation and goal-oriented mesh refinement for aerodynamic flows

R. Hartmann*

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

ABSTRACT

In this talk we present higher order and adaptive discontinuous Galerkin methods for an efficient and reliable prediction of aerodynamic force coefficients for aerodynamic flows. These methods will be applied to industrial test cases considered in the EU project ADIGMA [4].

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. By employing a duality argument error estimates can be derived for estimating the error measured in terms of aerodynamic force coefficients. The error estimate includes primal residuals multiplied by the solution to an adjoint problem related to the force coefficients. The error 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, [1,2,5].

The adjoint-based error estimation and goal-oriented mesh refinement for a discontinuous Galerkin discretization of the RANS-$k\omega$ equations as implemented in the PADGE code [3] will be applied to aerodynamic flows including a turbulent flow around the L1T2 three-element high lift configuration and a turbulent flow around the DLR-F6 wing-body configuration.

REFERENCES

[1] R. Hartmann, Multitarget error estimation and adaptivity in aerodynamic flow simulations, *SIAM J. Sci. Comput.*, **31**(1), pp. 708-731 (2008)

[2] R. Hartmann and P. Houston, Adaptive Discontinuous Galerkin Finite Element Methods for the Compressible Euler Equations, *J. Comput. Phys.*, **183**(2), pp. 508-532, (2002)

[3] R. Hartmann, J. Held, T. Leicht, and F. Prill, Discontinuous Galerkin methods for computational aerodynamics - 3D adaptive flow simulation with the DLR PADGE code, *Aerospace Science and Technology* (2010), In review

[4] N. Kroll, ADIGMA – A European project on the development of adaptive higher-order variational methods for aerospace applications, *47th AIAA Aerospace Sciences Meeting*, AIAA 2009-176, (2009)

[5] T. Leicht and R. Hartmann, Anisotropic mesh refinement for discontinuous Galerkin methods in two-dimensional aerodynamic flow simulations, *Int. J. Numer. Meth. Fluids*, **56**(11), pp. 2111-2138 (2008)