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Fluid Optimisation Workflows for Highly Effective Automotive Development Processes
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Title of Paper

State of the art at DLR in solving aerodynamic shape optimization problems using the discrete viscous adjoint method.

For Presentation as

Oral Paper

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Requirements for Oral Presentation

Video Beamer

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Abstract:

Numerical shape optimisation based on CFD methods is playing an increasing strategic role in aerodynamic aircraft design. It offers the possibility of designing or improving aircraft components with respect to a given objective, subject to geometrical and physical constraints. One of the most promising design strategies is the use of the adjoint formulation of the CFD solver for efficient and accurate computation of gradients in high-dimensional design spaces.

At the German Aerospace Center (DLR), activities focus on developing several key technologies relating to the establishment of an efficient and flexible numerical optimisation capability based on CFD and adjoint methods. These include suitable techniques for geometry parameterization, meshing and mesh movement methods, efficiency and accuracy improvements of the flow and adjoint solvers, as well as robust and efficient optimisers [1-3].

The presentation gives an overview of the current state of the art on the application of the discrete adjoint approach for solving various aerodynamic shape optimisation problems at DLR, Institute of Aerodynamics and Flow Technology. First the strategy to solve the flow adjoint problem and to efficiently compute the gradients is presented. In the second part, the presentation focuses on the application of the methods for optimising 2d geometries, ranking from drag minimisation at high- and low-speed conditions to inverse design problems where the goal is to find the geometry that fit a predefined pressure distribution. The application on 3d configurations is highlighted in the third and last part: the most complex design problems are here considered, like how to effectively suppress the flow separation onset at wing-fuselage intersection and how to optimise the wing shape of an aircraft considering the aero-elastic deformations. This latter was obtained by extending the adjoint methods to the coupled aero-structural system [4], which allows considering the "real" flight shape during the optimisation process.

On all the cases presented, the optimisations are successfully performed within a limited number of flows evaluations, emphasising the benefit of the adjoint approach in aircraft shape design.

[1] R. P. Dwight, J. Brezillon: "Efficient and Robust Algorithms for Solution of the Adjoint Compressible Navier-Stokes Equations with Applications", International Journal of Numerical Methods in Fluids, 60 (4), 365–389, 2008.

[2] M. Widhalm, J. Brezillon, C. Ilic, T. Leicht: "Investigation on Adjoint Based Gradient Computations for Realistic 3D Aero-Optimization", 13th AIAA/ISSMO Multidisciplinary Analysis Optimization Conference, 13-15 Sept. 2010, Fort Worth, USA.

[3] J. Brezillon, R.P. Dwight: "Applications of a discrete viscous adjoint method for aerodynamic shape optimisation of 3D configurations", CEAS Aeronautical Journal, DOI: 10.1007/s13272-011-0038-0, October 2011.

[4] M. Abu-Zurayk, J. Brezillon: "Shape Optimization Using the Aero-structural Coupled Adjoint Approach for Viscous Flows", EUROGEN 2011, 13-16 Sep 2011, Capua, Italy