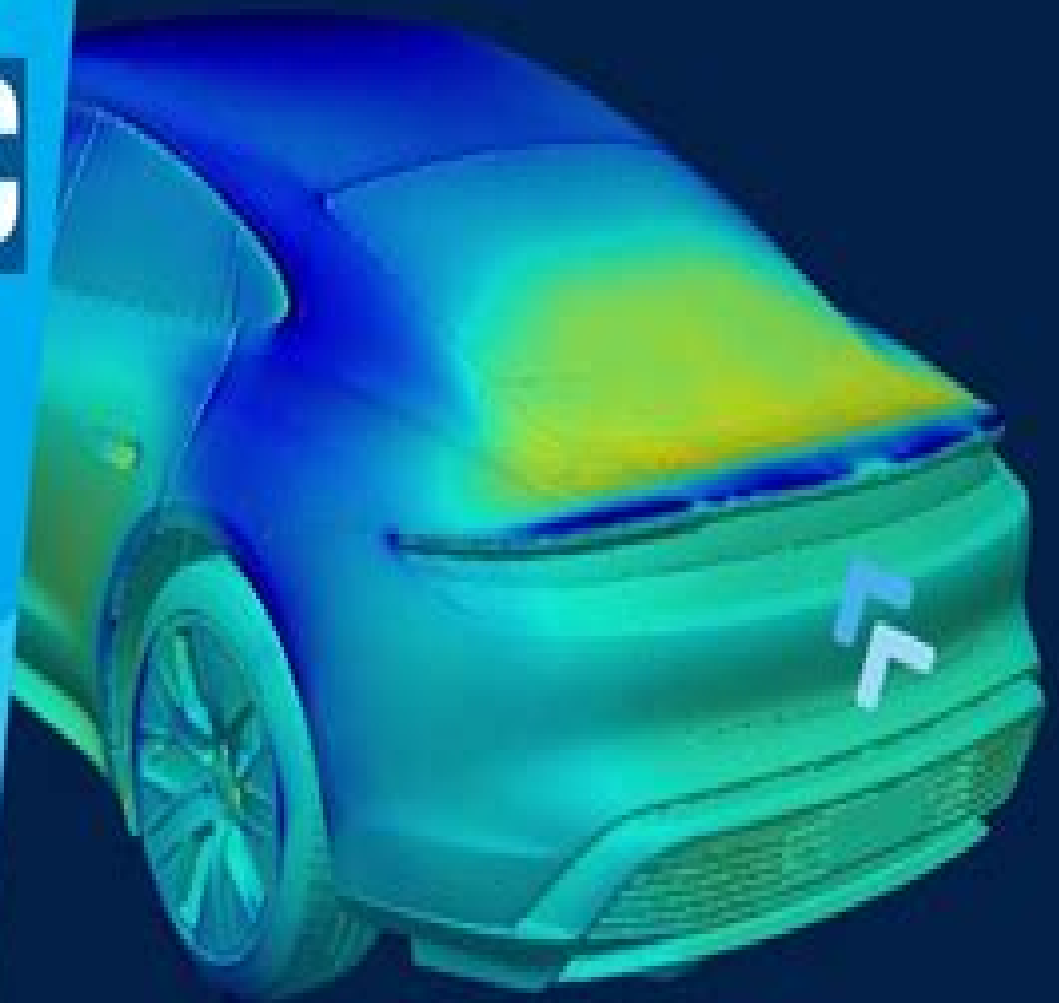


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# Aerodynamic Shape Optimization With The Adjoint Method

**Institute for Computer Applications in  
Science and Engineering, Angelo Iollo**

## **Aerodynamic Shape Optimization With The Adjoint Method:**

**Adjoint Methods for Aerodynamic Shape Optimization** Gábor Povorai, 2020 This master thesis investigated the applicability of the Hicks Henne bump functions and Free Form Deformation as shape deformation methods used for aerodynamic shape optimization by the adjoint method In order to alleviate user effort in the setup of simulations and post processing of results a MatLab framework has been developed This framework integrated shape definition meshing file management flow solver and post processing tools The external tools were open source software to allow the use of arbitrary cell and processor core numbers The computational fluid dynamics solver SU2 was used to obtain direct flow and adjoint solutions and to perform shape deformations using the built in nonlinear constrained optimization function Automatic mesh generation was done using GMSH The thesis focused on inviscid and viscous 2D problems in the transonic and supersonic flow regimes The definition of the initial aerodynamic shapes was done using the Class Shape Transformation method The test cases optimization problems with the NACA0012 airfoil as the initial airfoil for deformation with drag reduction as the objective function The test cases involved different constraints e g airfoil thickness lift coefficient and pitching moment coefficient Comparisons were made between the two methods in terms of performance in the minimization of the objective function The results of the optimization problems were compared to reference airfoils from literature Both deformation methods proved to be effective clear superiority of one method over the other could not be shown This master thesis investigated the applicability of the Hicks Henne bump functions and Free Form Deformation as shape deformation methods used for aerodynamic shape optimization by the adjoint method In order to alleviate user effort in the setup of simulations and post processing of results a MatLab framework has been developed This framework integrated shape definition meshing file manage

*ICGG 2020 - Proceedings of the 19th International Conference on Geometry and Graphics* Liang-Yee Cheng, 2020-12-01 This book covers various aspects of Geometry and Graphics from recent achievements on theoretical researches to a wide range of innovative applications as well as new teaching methodologies and experiences and reinterpretations and findings about the masterpieces of the past It is from the 19th International Conference on Geometry and Graphics which was held in S o Paulo Brazil The conference started in 1978 and is promoted by the International Society for Geometry and Graphics which aims to foster international collaboration and stimulate the scientific research and teaching methodology in the fields of Geometry and Graphics Organized five topics which are Theoretical Graphics and Geometry Applied Geometry and Graphics Engineering Computer Graphics Graphics Education and Geometry Graphics in History the book is intended for the professionals academics and researchers in architecture engineering industrial design mathematics and arts involved in the multidisciplinary field

**Advanced Computational Methods and Design for Greener Aviation** Tero Tuovinen, Jacques Periaux, Dietrich Knoerzer, Gabriel Bugeda, Jordi Pons-Prats, 2024-07-30 This book presents a selection of scientific and technical results utilizing new computational methods tools and technologies in Aeronautical Design Delve

into the forefront of aerospace technology with this collection of articles featuring insights from the from the ECCOMAS CM3 2021 Thematic Conference in Barcelona and from the Special Technology Sessions of the ECCOMAS Congress 2022 in Oslo Explore advancements in aeronautics design numerical methods and industrial technologies including aerodynamic optimization and additive manufacturing with contributions from leading experts and from research projects funded by the European Union Whether you re a seasoned professional or a student this volume offers invaluable insights into the future of aviation and transportation

An adjoint-based shape-optimization method for aerodynamic design Giampietro Carpentieri,2009 2023 Asia-Pacific International Symposium on Aerospace Technology (APISAT 2023) Proceedings Song Fu,2024-07-04 This book is a compilation of peer reviewed papers from the 2023 Asia Pacific International Symposium on Aerospace Technology APISAT2023 The symposium is a common endeavour among the four national aerospace societies in China Australia Korea and Japan namely Chinese Society of Aeronautics and Astronautics CSAA Royal Aeronautical Society Australian Division RAeS Australian Division Japan Society for Aeronautical and Space Sciences JSASS and Korean Society for Aeronautical and Space Sciences KSAS APISAT is an annual event initiated in 2009 It aims to provide the opportunity to Asia Pacific nations for the researchers of universities and academic institutes and for the industry engineers to discuss the current and future advanced topics in aeronautical and space engineering This is the volume II of the proceedings

**Aerodynamic Shape Optimization of Complex Aircraft Configurations Via an Adjoint Formulation** James Reuther,1996 Abstract This work describes the implementation of optimization techniques based on control theory for complex aircraft configurations Here control theory is employed to derive the adjoint differential equations the solution of which allows for a drastic reduction in computational costs over previous design methods 13 12 43 38 In our earlier studies 19 20 22 23 39 25 40 41 42 it was shown that this method could be used to devise effective optimization procedures for airfoils wings and wing bodies subject to either analytic or arbitrary meshes Design formulations for both potential flows and flows governed by the Euler equations have been demonstrated showing that such methods can be devised for various governing equations 39 25 In our most recent works 40 42 the method was extended to treat wing body configurations with a large number of mesh points verifying that significant computational savings can be gained for practical design problems In this paper the method is extended for the Euler equations to treat complete aircraft configurations via a new multiblock implementation New elements include a multiblock multigrid flow solver a multiblock multigrid adjoint solver and a multiblock mesh perturbation scheme Two design examples are presented in which the new method is used for the wing redesign of a transonic business jet *Aerodynamic Shape Optimization of Supersonic Aircraft Configurations Via an Adjoint Formulation on Parallel Computers* Research Institute for Advanced Computer Science (U.S.),1996 Abstract This work describes the application of a control theory based aerodynamic shape optimization method to the problem of supersonic aircraft design The design process is greatly accelerated through the use of both control theory and a parallel

implementation on distributed memory computers Control theory is employed to derive the adjoint differential equations whose solution allows for the evaluation of design gradient information at a fraction of the computational cost required by previous design methods [13, 12, 44, 38] The resulting problem is then implemented on parallel distributed memory architectures using a domain decomposition approach an optimized communication schedule and the MPI Message Passing Interface Standard for portability and efficiency The final result achieves very rapid aerodynamic design based on higher order computational fluid dynamics methods CFD In our earlier studies the serial implementation of this design method [19, 20, 21, 23, 39, 25, 40, 41, 42, 43, 9] was shown to be effective for the optimization of airfoils wings wing bodies and complex aircraft configurations using both the potential equation and the Euler equations [39, 25] In our most recent paper the Euler method was extended to treat complete aircraft configurations via a new multiblock implementation Furthermore during the same conference we also presented preliminary results demonstrating that this basic methodology could be ported to distributed memory parallel computing architectures [24] In this paper our concern will be to demonstrate that the combined power of these new technologies can be used routinely in an industrial design environment by applying it to the case study of the design of typical supersonic transport configurations A particular difficulty of this test case is posed by the propulsion airframe integration

*Shape Optimization Governed by the Euler Equations Using an Adjoint Method* Institute for Computer Applications in Science and Engineering, Angelo Iollo, 1993

**Advances in Energy Science and Equipment Engineering** Shiquan Zhou, Aragona Patty, Shiming Chen, 2015-11-05 Advances in Energy Equipment Science and Engineering contains selected papers from the 2015 International Conference on Energy Equipment Science and Engineering ICEESE 2015 Guangzhou China 30-31 May 2015 The topics covered include Advanced design technology Energy and chemical engineering Energy and environmental engineering Energy science

**Aerodynamic Shape Optimization Using Control Theory** James John Reuther, Research Institute for Advanced Computer Science (U.S.), 1996 Abstract Aerodynamic shape design has long persisted as a difficult scientific challenge due to its highly nonlinear flow physics and daunting geometric complexity However with the emergence of Computational Fluid Dynamics CFD it has become possible to make accurate predictions of flows which are not dominated by viscous effects It is thus worthwhile to explore the extension of CFD methods for flow analysis to the treatment of aerodynamic shape design Two new aerodynamic shape design methods are developed which combine existing CFD technology optimal control theory and numerical optimization techniques Flow analysis methods for the potential flow equation and the Euler equations form the basis of the two respective design methods In each case optimal control theory is used to derive the adjoint differential equations the solution of which provides the necessary gradient information to a numerical optimization method much more efficiently than is achieved by conventional finite differencing Each technique uses a quasi Newton numerical optimization algorithm to drive an aerodynamic objective function toward a minimum An analytic grid perturbation method is developed to modify body fitted meshes to accommodate

shape changes during the design process Both Hicks Henne perturbation functions and B spline control points are explored as suitable design variables The new methods prove to be computationally efficient and robust and can be used for practical airfoil design including geometric and aerodynamic constraints Objective functions are chosen to allow both inverse design to a target pressure distribution and wave drag minimization Several design cases are presented for each method illustrating its practicality and efficiency These include non lifting and lifting airfoils operating at both subsonic and transonic conditions

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