Aerodynamic Design Optimization Of A Kind Of Reentry

Abstract: "An all-at-once reduced Hessian Successive Quadratic Programming (SQP) scheme has been shown to be efficient for solving aerodynamic design optimization problems with a moderate number of design variables [1]. This paper extends this scheme to allow solution refining. In particular, we introduce a reduced Hessian refining technique that is critical for making a smooth transition of the Hessian information from coarse grids to fine grids. Test results on a nozzle design using quasi-one-dimensional Euler equations show that through solution refining the efficiency and the robustness of the all-at-once reduced Hessian SQP scheme are significantly improved."

An all-at-once reduced Hessian Successive Quadratic Programming (SQP) scheme has been shown to be efficient for solving aerodynamic design optimization problems with a moderate number of design variables. This paper extends this scheme to allow solution refining. In particular, we introduce a reduced Hessian refining technique that is critical for making a smooth transition of the Hessian information from coarse grids to fine grids. Test results on a nozzle design using quasi-one-dimensional Euler equations show that through solution refining the efficiency and the robustness of the all-at-once reduced Hessian SQP scheme are significantly improved. Feng, Dan and Pulliam, Thomas H. Ames Research Center NAS2-13721...

A Fully-coupled Algorithm for Aerodynamic Design Optimization

Computational Methods for Aerodynamic Design (Inverse) and Optimization

Formulation for Simultaneous Aerodynamic Analysis and Design Optimization

Aerodynamic Design Optimization of Proprotors for Convertible-rotor Concepts

Performance Evaluation and Improvements of CFD-based Aerodynamic Design Optimization

Rising fuel cost has motivated increased fuel efficiency for freight trains. At cruising speed, the largest contributing factor to the fuel consumption is aerodynamic drag. As a result of stagnation and flow separation on and around lead and trailing cars, the first and last railcars experience greater drag than intermediate cars. Accordingly, this work focused on reducing drag on lead locomotives by designing and optimizing an add-on nose fairing that is feasible for industrial operation.

Aerodynamic design, like many other engineering applications, is increasingly relying on computational power. The growing need for multi-disciplinarity and high fidelity in design optimization for industrial applications requires a huge number of repeated simulations in order to find an optimal design candidate. The main drawback is that each simulation can be computationally expensive – this becomes an even bigger issue when used within parametric studies, automated search or optimization loops, which typically may require thousands of analysis evaluations. The core issue of a design-optimization problem is the search process involved. However, when facing complex problems, the high-dimensionality of the design space and the high-multi-modality of the target functions cannot be tackled with standard techniques. In recent years, global optimization using meta-models has been widely applied to design exploration in order to rapidly investigate the design space and find sub-optimal solutions. Indeed, surrogate and reduced-order models can provide a valuable alternative at a much lower computational cost. In this context, this volume offers advanced surrogate modeling applications and optimization techniques featuring reasonable computational resources. It also discusses basic theory concepts and their application to aerodynamic design cases. It is aimed at researchers and engineers who deal with complex aerodynamic design problems on a daily basis and employ expensive simulations to solve them.

Automated Aerodynamic Design Optimization Process for Automotive Vehicle

Dasa Aerodynamic Design Optimization

Aerodynamic Design and Optimization in One Shot

Aerodynamic Design Optimization of Unstructured Grid with a Continuous Adjoint Formulation

Machine Learning Paradigms in Design Optimization: Applications in Turbine Aerodynamic Design

A fully-coupled algorithm is presented to solve aerodynamic design optimization problems. The discretized flow, adjoint, and optimality condition equations are solved as a single system of nonlinear equations using an inexact Newton method with linesearching. Quasi-1D, inverse, nozzle design and inviscid, 2D, inverse, airfoil shape design cases are solved, however the method is applicable to more general design cases. While the system is approximately twice as large as the system describing the flow solution, fewer iterations are required to find the optimum. The most important advantage of this method is that only a single flow solve is needed to perform the optimization, as opposed to the discrete adjoint method which requires several. Many improvements have been made to the algorithm, both in the system formation and solution method. The result is an algorithm that is reliable, robust, accurate, and fast in providing optimum solutions for the cases considered.

This volume presents up-to-date material on the state of the art in evolutionary and deterministic methods for design, optimization and control with applications to industrial and societal problems from Europe, Asia, and America. EUROGEN 2015 was the 11th of a series of International Conferences devoted to bringing together specialists from universities, research institutions and industries developing or applying evolutionary and deterministic methods in design optimization, with emphasis on solving industrial and societal problems. The conference was organised around a number of parallel symposia, regular sessions, and keynote lectures focused on surrogate-based optimization in aerodynamic design, adjoint methods for steady & unsteady optimization, multi-disciplinary design optimization, holistic optimization in marine design, game strategies combined with evolutionary computation, optimization under uncertainty, topology optimization, optimal planning, shape optimization, and production scheduling.

Acceleration of Aerodynamic Design Optimization Through Interleaving of Aerodynamic and Optimization Iterations
Aerodynamic Design Optimization of a Transonic Compressor Rotor
Geometry and Optimization
Advances in Evolutionary and Deterministic Methods for Design, Optimization and Control in Engineering and Sciences
A Fully-coupled Algorithm for Aerodynamic Design Optimization [microform]

A continuous adjoint approach for obtaining sensitivity derivatives on unstructured grids is developed and analyzed. The derivation of the costate equations is presented, and a second-order accurate discretization method is described. The relationship between the continuous formulation and a discrete formulation is explored for inviscid, as well as for viscous flow. Several limitations in a strict adherence to the continuous approach are uncovered, and an approach that circumvents these difficulties is presented. The issue of grid sensitivities, which do not arise naturally in the continuous formulation, is investigated and is observed to be of importance when dealing with geometric singularities. A method is described for modifying inviscid and viscous meshes during the design cycle to accommodate changes in the surface shape. The accuracy of the sensitivity derivatives is established by comparing with finite-difference gradients and several design examples are presented.

Computational Fluid Dynamics (CFD) has made remarkable progress in the last two decades and is becoming an important, if not inevitable, analytical tool for both fundamental and practical fluid dynamics research. The analysis of flow fields is important in the sense that it improves the researcher's understanding of the flow features. CFD analysis also indirectly helps the design of new aircraft and/or spacecraft. However, design methodologies are the real need for the development of aircraft or spacecraft. They directly contribute to the design process and can significantly shorten the design cycle. Although quite a few publications have been written on this subject, most of the methods proposed were not used in practice in the past due to an immature research level and restrictions due to the inadequate computing capabilities. With the progress of high-speed computers, the time has come for such methods to be used practically. There is strong evidence of a growing interest in the development and use of aerodynamic inverse design and optimization techniques. This is true, not only for aerospace industries, but also for any industries requiring fluid dynamic design. This clearly shows the matured engineering need for optimum aerodynamic shape design methodologies. Therefore, it seems timely to publish a book in which eminent researchers in this area can elaborate on their research efforts and discuss it in conjunction with other efforts.

Engineering Design Optimization

Aerodynamic Design Optimization Using the Navier-Stokes and Adjoint Equations

Aircraft Aerodynamic Design

Aerodynamic Design Optimization on Unstructured Grids with a Continuous Adjoint Formulation

Aerodynamic Design Optimization Via Reduced Hessian Sqp with Solution Refining

This thesis describes an application of adjoint-based adaptive meshing and shape optimization in a parallel computational setting. Adjoint solutions are leveraged to identify error-prone regions of the flow domain, refine the mesh in those regions, and improve the accuracy of a desired functional. The study is based on the Saturn V launch vehicle from the 1960's and 1970's Apollo program, from which the ascent trajectory and lower rocket geometry is derived. Two families of axis-symmetric fairing shapes are compared for drag performance in the subsonic to supersonic regimes. A fairing is sought with overall improvement in drag performance over the entire ascent trajectory, and a measurable quantity called 'drag loss' is introduced for this purpose. The computations are performed with the flow solver Cart3D on the Columbia supercomputer at NASA Ames Research Center.

The traditional side mirrors could create a substantial part of drag that is crucial in the car aerodynamic design consideration. Currently, digital side mirrors have been installed which are aiming to reduce the total automobile aerodynamic drag, thus the optimization study of car digital side mirrors configuration becomes an important task. In this study, the benchmark DrivAer fastback car model is employed for optimization work of digital side mirrors via computation fluid dynamics software, and numerically simulated with realistic moving ground and rotating wheel conditions. As a result, after careful selection of the incompressible flow solver and turbulence model, it could be found that the Sliding Mesh method provides the most accurate results in the three rotating techniques. For optimization work, a concept of digital side mirror configuration is created, and the objective is aiming for the best drag reduction via various installation positions by using the surrogate method which is based on Kriging model. For further drag reduction, the vortex generator is also considered. Current simulation results show for the best achieved digital side mirror and vortex generator location, it is observed that via a detailed fluid flow analysis, a positive effect of drag reduction from increasing the intensity of some specific vortices, and its wake region is also weaker than the original configuration. In addition, in order to cope with the fast-changing extreme or severe weather situations, the impacts of the important physical phenomena such as gust crosswind, heavy rain, and the cornering conditions are simulated and compared with each other as well. Among these three impacts, our numerical results show that the gust crosswind and cornering maneuver have the most negative influences on this car aerodynamic performance such as drag and side force, thus prove the usefulness of current approach in automobile design and safety considerations. In addition, the combination of the gust crosswind and heavy rain condition is also elaborated in our work, and result shows a similar linear trend to the previous simulation.

Three-dimensional Aerodynamic Design Optimization Using Discrete Sensitivity Analysis and Parallel Computing

Recent Improvements in Aerodynamic Design Optimization on Unstructured Meshes

Aerodynamic Design Optimization with Sensitivity Analysis and Computational Fluid Dynam ..., Oktay Baysai, Old Dominion University, May 1995

Probabilistic Inverse Aerodynamic Design Optimization for Natural Laminar Flow Wings

An adjoint-based shape-optimization method for aerodynamic design

A study was performed to evaluate the effects of different flow solvers, optimization methods, and design variables on aerodynamic design optimization. The Euler, Euler/boundary-layer, and compressible and incompressible Navier-Stokes equations were used for the flow analyses. Inverse design optimization used a least-square method to minimize pressure discrepancies between a target and the designed airfoils, and designs were performed for transonic airfoils and turbomachinery blades. Constrained design optimization, based on a modified feasible direction methods was used to improve the aerodynamic performance of single and multi-element airfoils with specified design constraints. The ease of implementation makes the finite-difference sensitivity derivative evaluation popular in many aerodynamic design optimization applications. The accuracy of finite-difference sensitivity derivatives was examined, and two methods were introduced to improve the accuracy. The first method is a modified finite-difference approach, which improves the accuracy of computed derivatives over the traditional approaches. The second method finds the optimum step size by using an asymptotic error formula to reduce errors in the sensitivity derivative evaluations. These two new methods were implemented for inverse and constrained design optimizations, exhibiting consistently better performances in both the design quality and the convergence of the design cycle, compared to the traditional finite-difference method. The direct differentiation method to calculate the sensitivity derivatives was also developed. Sensitivity equations were obtained by differentiating the Navier-Stokes equations with respect to design variables. The material derivative concept of continuum mechanics was implemented to obtain shape sensitivities. The sensitivity equations share the same Jacobian matrices with the Navier-Stokes equations and, therefore, the sensitivity analysis uses the same iterative integration scheme as the flow analysis. The analytical sensitivity method consistently gives accurate sensitivity derivatives, compared to the finite-difference sensitivity method. In order to evaluate the effects of the accuracy of sensitivity derivatives on the performance of design process, several inverse designs were performed using both analytical and finite-difference sensitivity derivatives. The results show that the design cycle converges faster, and hence costs less, when analytical sensitivity derivatives are used as opposed to finite-difference sensitivities.

An efficient approach for simultaneous aerodynamic analysis and design optimization is presented. This approach does not require the performance of many flow analyses at each design optimization step, which can be an expensive procedure. Thus, this approach brings us one step closer to meeting the challenge of incorporating computational fluid dynamic codes into gradient-based optimization techniques for aerodynamic design. An adjoint-variable method is introduced to nullify the effect of the increased number of design variables in the problem formulation. The method has been successfully tested on one-dimensional nozzle flow problems, including a sample problem with a normal shock. Implementations of the above algorithm are also presented that incorporate Newton iterations to secure a high-quality flow solution at the end of the design process. Implementations with iterative flow solvers are possible and will be required for large, multidimensional flow problems. Hou, G. W. and Taylor, A. C., III and Mani, S. V. and Newman, P. A. Langley Research Center NAG1-1265...

Aerodynamic Design Optimization Using Sensitivity Analysis and Computational Fluid Dynamics

On the Aerodynamic Design Optimization Considerations of Modern Automobile Configuration

Aerodynamic Design Optimization Via Reduced Hessian SQP with Solution Refining

Recent Development of Aerodynamic Design Methodologies

Aerodynamic Design Optimization Using Flow Feature Parameterization

Based on course-tested material, this rigorous yet accessible graduate textbook covers both fundamental and advanced optimization theory and algorithms. It covers a wide range of numerical methods and topics, including both gradient-based and gradient-free algorithms, multidisciplinary design optimization, and uncertainty, with instruction on how to determine which algorithm should be used for a given application. It also provides an overview of models and how to prepare them for use with numerical optimization, including derivative computation. Over 400 high-quality visualizations and numerous examples facilitate understanding of the theory, and practical tips address common issues encountered in practical engineering design optimization and how to address them. Numerous end-of-chapter homework problems, progressing in difficulty, help put knowledge into practice. Accompanied online by a solutions manual for instructors and source code for problems, this is ideal for a one- or two-semester graduate course on optimization in aerospace, civil, mechanical, electrical, and chemical engineering departments.

A Computational Aerodynamic Design Optimization Method Using Sensitivity Analysis
Topics and Approaches
Application of Surrogate-based Global Optimization to Aerodynamic Design
A Study on Aerodynamic Design Optimization Using an Adjoint Method
Aerodynamic Design Optimization Using Computational Fluid Dynamics