11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Structural and Aerostructural Design of Aircraft Wings with a Matrix-Free Optimizer

Andrew B. Lambe[1], Joaquim R. R. A. Martins[2]

[1] University of Toronto, Toronto, Canada, andrew.lambe@mail.utoronto.ca
[2] University of Michigan, Ann Arbor, Michigan, USA, jrram@umich.edu

Abstract

In structural optimization subject to failure constraints, computing the gradients of a large number of functions with respect to a large number of design variables may not be computationally practical. Often, the number of constraints in these optimization problems is reduced using constraint aggregation at the expense of a higher mass of the optimal structural design. This work presents results of structural and coupled aerodynamic and structural design optimization of aircraft wings using a novel matrix-free augmented Lagrangian optimizer [1,2]. By using a matrix-free optimizer, the computation of the full constraint Jacobian at each iteration is replaced by the computation of a small number of Jacobian-vector products. The low cost of the Jacobian-vector products allows optimization problems with thousands of failure constraints to be solved directly without resorting to constraint aggregation. The structural test problem is to minimize the mass of an aircraft wing structure subject to failure constraints at two loading conditions. The multidisciplinary problem is to design the wing to minimize the take-off weight of the aircraft for a design mission subject to lift constraints and failure constraints at one cruise condition and two maneuver conditions. The results indicate that the matrix-free optimizer reduces the computational work of solving the optimization problem by an order of magnitude compared to a traditional sequential quadratic programming optimizer. Furthermore, the use of a matrix-free optimizer makes the solution of large multidisciplinary design problems, in which gradient information must be obtained through iterative methods, computationally tractable.

References

[1] S. Arreckx, A. Lambe, J. R. R. A. Martins, and D. Orban. Implementation of a Matrix-Free Augmented Lagrangian Algorithm with Application to Aircraft Structural Design. *Optimization and Engineering*, 2015. (Accepted subject to revisions.)

[2] A. B. Lambe, and J. R. R. A. Martins, A matrix-free approach to large-scale structural optimization. 10th World Congress on Structural and Multidisciplinary Optimization. Orlando, FL. May 2013.