High-Fidelity Multidisciplinary Design Optimization for the Next Generation of Aircraft

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ABSTRACT

Multidisciplinary design optimization (MDO) has found many applications in engineering and is now positioned to make major contributions in the design of the next generation of aircraft. In particular, the simultaneous optimization of the outer mold line of a wing and its structural sizing yields an optimal aeroelastic tailoring for a given wing. However, due to the computational cost of computational fluid dynamics (CFD) and computational structural mechanics (CSM), as well as the number of cases that need to be considered, high-fidelity MDO of aircraft configurations remains a challenge.

A framework for high-fidelity aerostructural optimization will be presented along with the theory developed to address the inherent challenges. The framework combines a three-dimensional CFD solver, a finite-element solver capable of modeling composite layups, a geometry modeler, and a gradient-based optimizer to compute the flying shape of a wing and to optimize aircraft configurations with respect to aerodynamic shape and internal structural sizes. The theoretical developments to be presented include coupled sensitivity analysis methods, and an automatic differentiation adjoint approach. The algorithms resulting from these developments are all implemented to take advantage of massively parallel computers.

Applications to the optimization of aircraft configurations will demonstrate the effectiveness of these approaches. The results will include the study of aircraft weight versus fuel burn Pareto fronts for both metallic and composite wings. The presentation will end with a speculation on future research directions in this area.