Minimum drag planar wing configuration design using high-fidelity aero-structural optimization

Prateek Ranjan[1] and Kai A. James [2]
University of Illinois at Urbana-Champaign, Urbana, Illinois 61801

I. Project Description

Aerodynamic shape optimization is an effective design approach considered during the design process of lifting surfaces. Use of high-fidelity RANS-based solvers as a part of the shape optimization sub-routine for near-accurate estimation of drag and lift forces, allows for feasible and optimal wing designs at zero-to-low angles of attack. While an optimal aerodynamic shape results in minimization of drag subject to design constraints, further reductions in drag can be achieved in the form of induced drag minimization with the use of structural topology optimization. Advanced topology optimization algorithms allow for reductions in overall weight as well as minimization of structural compliance, for a given flight envelope.

A numerical framework encompassing both shape and structural optimization sub-routines will be developed. An open-source finite volume computational fluid dynamics toolkit will be used as a part of a larger shape-optimization framework, along with a linear finite element code for structural optimization. The main focus of the project will be on developing a mesh generation engine in three dimensions, for both finite volume and finite element computations and its incorporation into the optimization framework. The student researcher will be involved at all stages of development of the numerical framework as well as aerodynamic performance analysis using transient flow simulations, towards the end of the study.

II. Expected Research Activities

The project will involve comprehensive algorithm development on a C++ platform. The student will use the open-source finite volume code for computational fluid dynamics and an in-house finite element code, developed within the CDIL research group. Apart from learning about optimization algorithms and their application towards the design of optimal lifting surfaces, the student will also participate in advanced computational fluid dynamics analysis to study the performance of the resulting wing design.

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[1] Graduate Research Assistant, Department of Aerospace Engineering, pranjan2@illinois.edu
[2] Assistant Professor, Department of Aerospace Engineering, kaijames@illinois.edu