An Efficient Approach for Multi-Objective Robust Design

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ABSTRACT

Realistic engineering design in the field of computational fluid dynamics involves the optimization of different competing objectives. A further significant step to realistic multi-objective designs is to take into account uncertainties for finding robust optimal solutions.

In previous work[1] the authors combined multi-objective optimization and robust design using the epsilon-constraint approach together with the non-intrusive polynomial chaos approach. The proposed method was applied to an aerodynamic shape optimization problem. As the computational costs for solving the underlying partial differential equations are already very high, it is important to consider efficient approaches for uncertainty quantification and optimization.

Dimension-adaptive sparse grids[2] can be used to improve the computational performance of the non-intrusive polynomial chaos approach. In this method generalized sparse grids are produced with a dimension-adaptive strategy, in which the important dimensions are identified with the help of error estimators. In the epsilon-constraint method the multi-objective optimization problem is transformed into several constrained single-objective optimization problems. The computational effort for solving the sequence of these problems can be reduced by using a one-shot approach suited for constrained optimization problems[3]. In the one-shot optimization approach the state, the adjoint and the design are updated simultaneously. The needed derivatives are computed using algorithmic differentiation.

In Schillings et al.[4] dimension-adaptive sparse grids and the one-shot approach are used for single-objective aerodynamic robust design. Our aim is to extend the robust multi-objective optimization approach in a similar way to reduce the computational effort. We validate our suggested methodology for minimizing drag and maximizing lift in a steady Euler flow considering uncertainties in the flight conditions and in the geometry.

References

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