# Robust Design in the Context of Deterministic Multi-Objective Optimization

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**ABSTRACT**

Realistic engineering design involves the optimization of different competing objectives. Here, the aim is to find a set of solutions that fulfill the concept of Pareto optimality. A further significant step to realistic multi-objective designs is to take into account uncertainties for finding robust optimal solutions.

There exist different methods to propagate uncertainties in the model. As the costs of a multi-objective optimization are already very high, it is important to use efficient approaches. In Schillings et al.[1], a non-intrusive polynomial chaos approach is used for single-objective aerodynamic robust design. In this approach the stochastic objective function is expanded in terms of polynomials that are orthogonal with respect to the density function of the input random variables. The non-intrusive approach results in a multiple set-point problem. The computational effort can be reduced by using sparse grids for the quadrature points. In Schillings et al.[1] the method is combined with one-shot optimization. It is shown that the used approach is efficient for expensive aerodynamic design problems.

Our aim is to find a suitable approach for combining multi-objective optimization and robust design. So far, multi-objective robust design is mainly treated in an evolutionary context (see e.g. [2]). Multi-objective evolutionary algorithms are usually computationally expensive and slow in terms of convergence. We make use of the deterministic Epsilon-Constraint Method[3] and extend the robust design approach of Schillings et al.[1] to multi-objective design problems. The concept of the Epsilon-Constraint Method is to optimize one objective function while imposing inequality constraints on the remaining competing objective functions. The constraints as well as the objective function to be optimized is varied to find different Pareto optimal solutions that are evenly distributed. For solving the sequence of these constrained single-objective optimization problems we will make use of deterministic optimization strategies using algorithmic differentiation[4] (AD) for the computation of derivatives. We validate our suggested methodology for robust multi-objective design.

## References

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