Machine-learning based approach to global optimization and interactive design

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The widespread availability of high-performance computing enables the use of disruptive new approaches to digital design, which are based on machine learning.

Within this contribution, we combine two such approaches and demonstrate their usefulness for the AUDI AG development workflow considering a production vehicle.

First, we demonstrate how surrogate based optimization can be used to quickly and efficiently identify the global optimum in a multi-dimensional parameter space. Second, we show how the data generated during the optimization process can be reused within a reduced-order-model based design space exploration tool, which allows for the effective collaboration of different departments, e.g. engineering and design, and for the efficient use of wind tunnel test time.

The methodology is first demonstrated on the generic DrivAer model, which is parameterized in six dimensions, three of which rely on topology morphing and the other three on the translational and rotational movement of the rear spoiler. OpenFOAM RANS simulations on a 30m cells mesh are used to generate the data for the methods.

The optimization aims at minimizing drag. It comprises two steps: Firstly, a space filling sampling plan with respect to the parameter space is produced. The respective simulations are performed, and the target function is evaluated (i.e. the drag coefficient is calculated). Based on this information a surrogate model is calculated, which is, secondly, used to identify those regions in the parameter space, which promise the highest potential for improvement. An iterative evaluation of the target function through simulation, each updating the surrogate model, leads to a quick and robust identification of the global optimum.

The simulation data from the optimization process can be reused to identify further suitable design variants. Reduced order modelling and interpolation methods, together with a graphical design tool, allow to explore the parameter space. This approach enables the engineer to instantaneously predict the flow field, scalar values such as the drag coefficient,

and the vehicle geometry for arbitrary parameter combinations. Such a method can be used for the real-time cooperation of different disciplines, e.g. engineering and design.

In addition, we demonstrate the successful optimization of the active rear spoiler position of the AUDI AG A7 production vehicle, where also the benefits of working with a graphical, interactive design tool become obvious.