Uncertainty Propagation for Aerospace Applications utilizing Surrogate Models

Lecture of

Philipp Bekemeyer

Institute of Aerodynamics and
Flow Technology, DLR Germany

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Pockelsstraße 3
38106 Braunschweig

Uncertainties are inherently present in every engineering system. In many day-to-day scenarios they are either ignored entirely or converted into deterministic measures such as safety factors. While this is a straightforward approach of handling uncertainties there is an undeniable risk that potentials are not fully exploited and portions of the system behavior remain hidden. Especially when looking into new technologies and configurations within the aeronautics field that features already highly optimized systems it becomes increasing challenging to achieve further improvements. A more rigorous quantification and propagation of uncertainties could provide further opportunities to improve designs and derive robust technologies. When expensive simulations tools such as computational fluid dynamics are involved rigorously accounting for uncertainties becomes a challenge because classical Monte Carlo methods are computationally infeasible. In this presentation we showcase how surrogate models can be utilized to quantify and propagate uncertainties for aeronautics cases. Within the so-called surrogate-based uncertainty quantification framework one or multiple surrogate models are trained and iteratively refined for quantities of interest, e.g. the drag coefficient and the surface pressure distribution, and afterwards used for uncertainty propagation. This yields accurate and reliable results at significantly reduced computational cost. The methodology is demonstrated for two aircraft configurations. One of them features large portions of laminar flow which is beneficial for fuel consumption but highly sensitive to uncertainties while the other configuration is highly flexible calling for fluid-structure coupled simulations and therefore further increasing the complexity of the underlying analysis. Besides the surrogate-based uncertainty quantification framework, the existence and handling of uncertainties is discussed for which only bounds are known and no explicit probability density function can be defined. With these techniques at hand aerospace engineers are now able to propagate uncertainties through expensive simulation tools. This is an essential step towards certification by analysis and also allows to account for uncertainties

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