60. Aerodynamic Design with Physics-Based Surrogates

Emiliano Iuliano, Domenico Quagliarella

Details, references and guidelines are given about the adoption of surrogate models and reduced-order models within the aerodynamic shape optimization context. The aerodynamic design problem and its approximated version are introduced and discussed and then, an overview of various surrogate models and surrogate-based optimization methods is given. Subsequently, the concept of model order reduction is recalled, and the performance analysis of reduced-order models based on proper orthogonal decomposition (POD) is discussed. Within this context, some techniques to adaptively and globally improve the accuracy of POD-based surrogates are illustrated. Finally, an aerodynamic shape design problem of a transonic airfoil is used to practically analyze and compare the performances of various surrogate-based optimization methods.

Modern air vehicle design has been increasingly driven by environmental as well as operational constraints. Environmental concerns, including emissions and noise, are gaining increasing importance in the design and operations of commercial aircraft. Taking into account the current prognoses for the growth in air traffic, the above-mentioned challenges become even more significant [60.1–4]. In this context, the development and assessment of new theoretical methodologies represents a cornerstone for reducing the experimental load, exploring trade-offs, and proposing alternatives along the design path. The fidelity of such methods is essential to reproduce *real-life* phenomena with a significant degree of accuracy and to take them into account from the very beginning of the design process. Due to the intrinsic complexity of aircraft design, the design space is often huge and difficult to explore fully, so that fast semi-empirical tools and rules [60.5–7], derived from classical configuration data, have been traditionally applied. However, they exhibit a severe lack of accuracy when designing novel and unconventional concepts. Therefore, highly accurate analysis methods have been continuously introduced both in geometric representation and physical modeling, but the main drawback