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ADAPTIVE SAMPLING CRITERIA FOR MULTI-FIDELITY METAMODELS IN CFD-BASED SHAPE OPTIMIZATION

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Complex industrial applications demand the use of high-fidelity CFD solvers with large computational grids to assess accurately the hydrodynamic performance and make reliable design decisions. The latter can be achieved by combining the CFD analysis with a shape/design modification tool and a minimization algorithm into an automatic simulation-based design optimization (SBDO) procedure. The use of high-fidelity computationally-expensive CFD analyses can make the SBDO unaffordable for most users and projects for which limited computational resources and time are usually available. Metamodels have been developed and widely used to reduce the computational cost of the SBDO in many engineering areas. A further reduction of the computational cost can be achieved through multi-fidelity metamodels. These combine the accuracy of high-fidelity simulations with the computational cost of low-fidelity simulations. Different fidelity levels are given by the physical model (e.g. RANS and potential flow) and/or by the computational grid size. One of the major challenge is the definition of an appropriate multi-fidelity training set able to represent efficiently the desired response. The paper presents a study on adaptive sampling criteria for multi-fidelity metamodeling for CFD-based shape optimization. Four adaptive sampling criteria are assessed in terms of efficiency and effectiveness in representing the desired response [1]. The proposed sampling criteria are based on i) prediction uncertainty, ii) design performance expected improvement, iii) prediction uncertainty and design performance combined in an aggregate function, and iv) uncertainty and performance with a multi-objective approach. The study is performed for the shape optimization of a NACA four-digit hydrofoil [2], using a RANS solver which performs multi-fidelity simulations through two levels of adaptive grid refinement [3].

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