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FULL-FIELD MULTI-FIDELITY SURROGATE ASSISTED OPTIMIZATION AND THEIR APPLICATION TO THE OPTIMAL DESIGN OF TURBOMACHINES

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Abstract: The design of complex engineering systems relies more and more on Multi-Disciplinary Optimization. Surrogate-Based Optimization methodologies have been considered for the past decades as a potential solution to alleviate the computational burden of modern optimization campaigns. Nevertheless, the usage of high-fidelity simulations within Surrogate-Based Optimization loops can be unaffordable especially for high-dimensional problems. Multi-fidelity surrogate modeling can be an excellent way to improve the quality of surrogates while maintaining the computational cost of the training phase within acceptable limits. In this contribution, we propose an infill strategy dedicated to optimizations accelerated by recent multi-fidelity non-intrusive proper orthogonal decomposition based surrogate models. These surrogates allow for a fast prediction of the vectorial information associated to the behavior of a given configuration. They take roots in the re-interpretation of the concept of the constrained POD (CPOD) to enrich the reduced order model of the high-dimensional output space, obtained from precise albeit costly high-fidelity simulations, with abundant yet less accurate lower-fidelity data. Multi-fidelity surrogate models on the obtained POD projection coefficients are then used to link, at virtually no extra cost, any parameter set in the design space to its high-dimensional response. To integrate these surrogate models into efficient Surrogate-Based Optimization loops, we propose an infill strategy targeting the selection of promising zones in the design space while restraining the computation burden affordable. This strategy selects not only the potentially efficient sets of parameters depending on their objectives and feasibility, but also tries to identify the level of fidelity necessary to equilibrate the CPU cost ratio between the available solvers. Both the POD bases and the surrogate models on the projection coefficients are improved along the optimization process to reach a satisfactory compromise. The performances of the proposed algorithm are discussed and compared with contributions using the aforementioned multi-fidelity POD based surrogate models on both analytical and industrial optimization problems.