Multifidelity Bayesian Methods for Design Optimization: Marine Engineering Application

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ABSTRACT

The design and optimization of marine engineering systems require the implementation of high-fidelity models capable to accurately represent complex physical phenomena. This is the case of computational fluid dynamic models for the numerical solution of partial differential equations that permit to accurately represent complex non-linear hydrodynamic phenomena. However, simulation-based optimization demand for a large number of model evaluations during the search for the optimal design, posing significant challenges in terms of computational resources associated with the implementation of high-fidelity models. To address this issue, we propose the use of multifidelity methods to combine information from physics-based models at different levels of fidelity, leveraging fast low-fidelity data to explore design configurations and refine the accuracy of the solution through wisely selected high-fidelity data [1-3]. This work compares popular multifidelity Bayesian optimization frameworks to accelerate the design analysis and enhance the performance of the hydrodynamic optimization procedure. In particular, we implement three formulations of the acquisition function to investigate the performance of a variety of adaptive sampling schemes realizing different trade-offs between exploration and exploitation. We demonstrate the capabilities of multifidelity Bayesian algorithms for the hydrodynamic constrained shape optimization of the DTMB 5415 hull: the goal is to minimize the resistance force in calm water. We observe that the multifidelity approaches permit to identify superior design solution if compared with standard single-fidelity Bayesian approaches.

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