Parameter space and model order reduction for the structural optimization of passenger ships

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ABSTRACT

In this talk we present a surrogate-based design optimization method involving parameter space reduction and reduced order modeling [1]. We focus on the structural optimization of passenger ship hulls. We exploit proper orthogonal decomposition (POD) to reduce the dimensionality of the stress tensor field and the active subspaces technique for the parameter space. We propose a multi-fidelity approach, where the low-fidelity model is built through parameter space reduction without the need of running any simplified simulation [2]. We integrate a low-dimensionality bias within a nonlinear autoregressive scheme of Gaussian processes. We apply this method to every POD modal coefficient. Then, we interpolate the latent variables to reconstruct the solution manifold and predict the state for unseen parameters.

The Bayesian optimization loop is performed using this surrogate model. The approximated optima are validated through high-fidelity simulations and the reduced order models are updated with this new information, resulting in better accuracy in the neighborhood of these added points. Thus, the surrogate model is driven by the optimizer to be accurate in regions with high potential, while accepting more uncertainty in the rest of the design space.

We implemented the numerical pipeline using ATHENA [3] for the active subspaces reduction, and EZyRB [4] for the proper orthogonal decomposition with interpolation method.

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