

Data-driven Parameterization Refinement for the Structural Optimization of Cruise Ship Hulls

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ABSTRACT

In the early design phase of a cruise ship, the designers need to ensure the structural resilience of the hull against extreme waves while reducing steel usage and being subjected to regulatory and manufacturing constraints. Finite Element Analysis (FEA) is crucial for the validation of the designs, but the long time required for the simulation of large-scale models prevents rapid prototyping and exploration of different design choices. Reduced order modeling can be leveraged to optimize a less accurate model, but computationally cheap model, with only the most promising designs being validated with the expensive FEA.

In [1], the authors propose a computational pipeline based on proper orthogonal decomposition and Gaussian process regression, which employs active subspaces and multi-fidelity modeling to efficiently optimize a full ship with 16 parameters. However, the choice of parameters often limits the efficacy of the optimization process: a formulation that can not express the optimal stress configuration leads to sub-optimal results.

In this talk we present an extension of [1] with a reparameterization module, which leverages the surrogates and integer linear programming to hierarchically refine the problem parameters based on the optimization process. Moreover, we show that the implementation of a multi-objective optimization module further enhances the exploration of the parametric domain and the identification of efficient trade-offs between different quantities of interest [2]. The new pipeline is tested on a simplified midship section and a full ship hull, comparing the automated reparameterization to a baseline model provided by the designers. The tests show that the iterative refinement outperforms the baseline on the more complex hull, proving that the pipeline streamlines the initial design phase, and helps the designers tackle more innovative projects.

REFERENCES

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