Design-Space Dimensionality Reduction in Structural Optimization via Parametric Model Embedding

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ABSTRACT

Simulation-driven optimization allows us to identify innovative design solutions and new concepts. High-fidelity prime-principle-based solvers provide accurate design performance analyses, while optimization algorithms drive the search for the desired optimal solution. This process is usually computationally (very) costly especially if global optimization is sought after, as (i) high-fidelity solvers are computationally expensive and (ii) many design performance evaluations are needed in global optimization, facing the so-called curse of dimensionality. One possible remedy is to use surrogate models and supervised machine learning in general, also relying on multi-fidelity or multi-source information as training data with adaptive sampling procedures [1]. A second remedy is to use unsupervised machine learning to reduce the design space dimensionality, thus alleviating the curse of dimensionality by directly tackling its main cause. Recently, the authors have developed a methodology, called parametric model embedding (PME), for the design space dimensionality reduction of parametric models in shape optimization [2] for hydrodynamic applications. The objective of the present work is to introduce and discuss the extension of PME to structural optimization problems. The PME data matrix uses structure-relevant features here, such as, e.g., section moments and stiffness coefficients, along with the model parameters. This allows us to identify the most important (principal) directions in the design space and therefore limit the design space exploration to those directions only. PME is demonstrated for the dimensionality reduction and structural optimization of a 40 ft generic prismatic planing hull (GPPH) slamming in waves at high speed [3].

REFERENCES

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