

PROCEEDINGS

Harnessing Diffusion Models for Multi-Objective Ship Hull Design

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ABSTRACT

Designing ship hulls under multiple and potentially competing objectives remains challenging because conventional optimization pipelines are often constrained by expensive simulations, limited search efficiency, and weak generative diversity. This study investigates diffusion models as a unified framework for multi-objective ship hull design, with an emphasis on controllable generation under diverse design goals. We explore several guidance strategies, including surrogate-model-based guidance, reinforcement learning for optimization of diffusion parameters during sampling, and classifier-free guidance. The proposed framework is evaluated in two representative scenarios. The first considers two uncorrelated hydrodynamic objectives defined by wave drag coefficient under different operating conditions, characterized by varying speed and draft, thereby examining how guidance methods balance performance across condition-dependent objectives. The second considers mixed geometric-physical objectives, in which wave drag coefficient is optimized jointly with hull depth, defined as a fraction of hull length, to assess the ability of each strategy to manage objectives with physical meanings. Through systematic comparison, we analyze how different guidance mechanisms influence trade-offs among objective satisfaction and controllability. The study aims to clarify the relative strengths and limitations of different generative strategies, including when simple guidance is sufficient and when specific strategies provide greater robustness. These findings offer practical insights into diffusion-based generative design for multi-objective-driven ship hull optimization.

KEYWORDS

Diffusion models; ship hull design; multi-objective; wave drag coefficient

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