Accelerating simulation-driven optimisation of marine propellers using shape-supervised dimension reduction

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ABSTRACT

Simulation-driven shape optimisation (SDSO) of marine propellers is often obstructed by high-dimensional design spaces stemming from its complex geometry and baseline parameterisation, which leads to the notorious curse of dimensionality. In this study, we propose using the shape-supervised dimension reduction (SSDR) approach to expedite the SDSO of marine propellers by extracting latent features for a lower-dimensional subspace. SSDR is different from other dimension reduction approaches as it utilises a shape-signature vector (SSV) function, which consists of a shape modification function and geometric moments, maximising the retained geometric and physical information in the subspace. The resulting shape-supervised subspace from SSDR enables us to efficiently and effectively find an optimal design in appropriate areas of the design space. The feasibility of the proposed method is tested for the E779A propeller parameterised with 40 design parameters with the objective to maximise efficiency while reducing suction side cavitation. The results demonstrate that the shape-supervised subspace achieved an 87.5\% reduction in the original design space's dimensionality, resulting in faster optimisation convergence.