Shape optimization through proper orthogonal decomposition with interpolation and dynamic mode decomposition enhanced by active subspaces

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ABSTRACT

We propose a numerical pipeline for shape optimization in naval engineering involving two different non-intrusive reduced order method (ROM) techniques. Such methods are proper orthogonal decomposition with interpolation (PODI) and dynamic mode decomposition (DMD). The ROM proposed will be enhanced by active subspaces (AS) as a pre-processing tool that reduce the parameter space dimensionality and suggest better sampling of the input space.

We will focus on geometrical parameters describing the perturbation of a reference bulbous bow through the free form deformation (FFD) technique. The ROM are based on a finite volume method (FV) to simulate the multi-phase incompressible flow around the deformed hulls.

In previous works we studied the reduction of the parameters space in naval engineering through AS [1, 3] focusing on different parts of the hull. PODI and DMD have been employed for the study of fast and reliable shape optimization cycles on a bulbous bow in [2].

The novelty of this work is the simultaneous reduction of both the input parameter space and the output fields of interest. In particular AS will be trained computing the total drag resistance of a hull advancing in calm water and its gradients with respect to the input parameters. DMD will improve the performance of each simulation of the campaign using only few snapshots of the solution fields in order to predict the regime state of the system. Finally PODI will interpolate the coefficients of the POD decomposition of the output fields for a fast approximation of all the fields at new untried parameters given by the optimization algorithm. This will result in a non-intrusive data-driven numerical optimization pipeline completely independent with respect to the full order solver used and it can be easily incorporated into existing pipelines, from the reference CAD to the optimal shape.

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