Shape Optimization of a Naval Destroyer by Multi-Fidelity Methods

A. Serani[1*], S. Ficini[1], R. Broglia[1], M. Diez[1], O. Goren[2], D. B. Danisman[2], H. Pehlivan Solak[2], S. Yıldız[2], M. Nikbay[2], T. Scholcz[3], J. Klinkenberg[3], G. Grigoropoulos[4], C. Bakirtzoglou[4], and G. Papadakis[4]

[1]National Research Council-Institute of Marine Engineering (CNR-INM), Rome, Italy
e-mail: andrea.serani@cnr.it

[2]Istanbul Technical University (ITU), Istanbul, Turkey
e-mail: ogoren@itu.edu.tr

[3]Maritime Research Institute Netherlands (MARIN), Wageningen, The Netherlands
e-mail: t.p.scholcz@marin.nl

[4]National Technical University of Athens (NTUA), Athens, Greece
e-mail: gregory@central.ntua.gr

ABSTRACT

The paper presents and discusses the so-called L3 sea benchmark problems [1] used to develop and assess multi-fidelity (MF) optimization methods for military vehicle design within the AVT-331 Research Task Group on ``Goal-driven, multi-fidelity approaches for military vehicle system-level design." The hull-form design of the DTMB 5415 model is addressed for optimal resistance and seakeeping performance in calm water, regular/irregular waves, and formulated as a global optimization problem. The design performance is assessed using a variety of physical models and solvers (including RANS and potential flow models), and spatial discretizations, which are combined together in dedicated MF frameworks, summarized in Tab. 1. Benchmark problems description, design parameterization methods, physical models and solvers are presented and discussed, as well as MF approaches and example results. The present effort highlights how the dimensionality of the optimization problem may be a critical issue for surrogate-model training. Nevertheless, it will be shown how the proposed MF approaches are able to achieve significant design performance improvements, even if only a few high-fidelity computations are used, with a ratio between the number of high- and low-fidelity evaluations required to solve the global optimization problem as low as nearly 1/50. Finally, the challenges arisen during the process are discussed and future research directions outlined.

Table 1: Multi-fidelity optimization frameworks

Framework	Problem	Parameterization	Solver(s)	MF approach	Group
A	Calm water	FFD/PME	RANS, PF	SRBF	CNR-INM
	Seakeeping	FFD/PME	RANS, PF	SRBF	CNR-INM
B	Calm water	FFD	RANS (multi grid)	SRBF	CNR-INM
C	Calm water	Akima	RANS, PF	KG	ITU
D	Calm water	Blending	RANS (multi grid)	KG	MARIN
E	Calm water and seakeeping	CAESES	RANS, PF	Mixed-ANN	NTUA

REFERENCES

[1] Beran, P. S., Bryson, D., Thelen, A. S., Diez, M. and Serani, A. Comparison of multi-fidelity approaches for military vehicle design, AIAA AVIATION 2020 FORUM, p. 3158, (2020).