An assessment of multifidelity procedures for ship hull form optimisation

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Research is being done at MARIN on adequate optimisation methods for ship afterbody design, in particular to reduce stern wave making. A full computational optimisation using free-surface RANS codes requires substantial computational effort. Therefore, approaches are being sought to accelerate the process, specifically by using surrogate-based optimisation with surrogates derived from Multi Fidelity (MF) formulations.

The paper will briefly describe the experiences collected so far. The multifidelity procedure considered consists of a nonlinear free-surface potential flow code as a Low-Fidelity (LF) method, and a free-surface RANS code as a High Fidelity (HF) method. A study for a fast displacement vessel, for which resistance had to be minimised for two speeds, has been reported in [1]. Here, a MF approach was most successful. For a containership however, the occurrence of wetted transoms for part of the design variants destroyed the correspondence of the LF and HF results.

The paper will discuss recent progress made. The baseline MF formulation used is an additive formulation, with or without a scale factor determined separately. The alternative cokriging method is reassessed based on several analytical examples, and is shown to require a fair correspondence of trends from the HF and LF methods. Even a limited shift of the optimum between LF and HF results can incidentally cause cokriging to perform quite poorly. In addition, the associated uncertainty given by the method relates weakly with the local error, making its use for adaptive sampling somewhat doubtful. Similar limitations apply to the more straightforward additive MF method.

Examples will be shown of the presence or absence of agreement of low and high-fidelity methods. We will consider free-surface potential flow, coarse-grid RANS solutions, RANS with linearised free surface, or double-body RANS solutions as LF method, depending on the case at hand. As a by-product, the comparison of LF and HF trends provides useful information on the flow physics and range of validity of the LF approximations.

A multifidelity optimisation of the standard benchmark case model 5415, also addressed in some other papers, e.g. [2,3], will be carried out using one of the MF formulations described; demonstrating some of the aspects discussed.

REFERENCES

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