Dimension reduction in heterogeneous parametric spaces: a naval engineering case

Marco Tezzele[†*], Filippo Salmoiraghi[†], Andrea Mola[†] and Gianluigi Rozza[†]

[†] SISSA, the International School for Advanced Studies,
Via Bonomea, 265, 34136 Trieste, Italy
e-mail: mtezzele@sissa.it, web page: http://mathlab.sissa.it/

ABSTRACT

We present the results of the first application in the naval architecture field of a new methodology for parameters space reduction. The physical problem considered is that of the simulation of the hydrodynamic flow past the hull of a ship advancing in calm water. Such problem is extremely relevant at the preliminary stages of the ship design, when several flow simulations are tyipically carried out by the engineers to assess the dependence of the hull total resistance on the geometrical parameters of the hull. Given the high number of geometric and physical parameters which might affect the total ship drag, the main idea of this work is to employ the active subspace method to identify possible lower dimensional structures in the parameters space. Thus, a fully automated procedure has been implemented to produce several perturbations of an original hull CAD geometry, use the resulting shapes to run high fidelity flow simulations with different structural and physical parameters as well, and collect data for the active subspace analysis. The free form deformation procedure used to morph the hull shapes [4], the high fidelity solver based on potential flow theory with fully nonlinear free surface treatment [1, 2], and the active subspace analysis tool employed in this work [3] have all been developed at MathLab the applied mathematics lab of SISSA, the International School for Advanced Studies at Trieste. The contribution will discuss several detail of the implementation of such tools, as well as the results of their application to the target engineering problem.

REFERENCES

[1] Mola, A. and Heltai, L. and DeSimone, A. *A stable and adaptive semi-Lagrangian potential model for unsteady and nonlinear ship-wave interactions*, Engineering Analysis with Boundary Elements, Vol 37, pp. 128–143.

[2] Mola, A. and Heltai, L. and DeSimone, A. *A Fully Nonlinear Semi-Lagrangian Potential Model for Ship Hydrodynamics Simulations Directly Interfaced with CAD Data Structures*, Proceedings of the Twenty-fourth (2014) International Ocean and Polar Engineering Conference, Vol. 4, pp. 815–822.

[3] Constantine, P. G. *Active subspaces: Emerging ideas for dimension reduction in parameter studies*, volume 2. SIAM, 2015.

[4] *PyGeM: Python Geometrical Morphing.* https://github.com/mathlab/pygem