9th Conference on Computational Methods in Marine Engineering (Marine 2021)
2–4 June 2021, Edinburgh, Scotland, UK

MODEL ORDER REDUCTION METHODS IN MARINE ENGINEERING

Marco Tezzele[1], Nicola Demo[2], Andrea Mola[3] and Gianluigi Rozza[4]

Mathematics Area, mathLab, SISSA, via Bonomea 265, I-34136 Trieste, Italy
[1] marco.tezzele@sissa.it
[2] nicola.demo@sissa.it
[3] andrea.mola@sissa.it
[4] gianluigi.rozza@sissa.it

Key Words: Reduced Order Modeling, Parameter Space Reduction, Uncertainty Quantification, Multi-objective Optimization

In marine engineering field many problems require a huge computational resources to be treated in a proper way. Reduced order modeling offers a (problem-dependent) simplification of the studied model, such that we are able to simulate the same phenomenon with a comparable accuracy with respect to the original model but with a reduced computational cost.

Among all possible approaches to reduce the complexity, reduced basis (RB) method [1] has gained popularity in the analysis of parametric systems, not only on the academic side, but also in several industrial contexts. This methodology uses the solutions of the discrete problem at a limited set of parameters, to construct an optimal basis which is able to efficiently represent approximated solution fields for new parameters.

Other non-intrusive reduced order methods such as Proper Orthogonal Decomposition with Interpolation (PODI) [2, 7] and Dynamic Mode Decomposition (DMD) [5] have gained attentions in marine engineering in the last years as enablers for accurate many-query problems. The non-intrusiveness allows an easy integration into existing industrial numerical pipelines, while the accuracy and the computational savings make possible the optimization of quantities of interest computed from more and more complex systems. Moreover, nowadays, the complexity is also due to the increase of the input design parameters. To fight the so-called curse-of-dimensionality we need to reduce not only the output fields but also the parameter space dimensionality by linear or nonlinear techniques [4, 6].

The aim of this invited session is to foster a proficuous discussion on the applicability of advanced reduced order methods to modern marine engineering simulations. We bring together a diverse spectrum of techniques [2], for both input parameters and output fields reduction [3]. This can benefit the design phase, giving unexpected insights on the studied system with respect to geometrical parameters, but can also greatly accelerate optimization campaigns exploiting real time reduced order models evaluations.

We encourage contributions regarding but not limited to multiobjective and shape optimization, uncertainty propagation and quantification, parameter space reduction, sensitivity analysis, and inverse problems, in the context of intrusive or non-intrusive reduced order methods applied to marine engineering.

REFERENCES

[1] J. S. Hesthaven, G. Rozza, B. Stamm, et al. *Certified reduced basis methods for parametrized partial differential equations*. Springer (2016).

[2] M. Tezzele, N. Demo, A. Mola, and G. Rozza. An integrated data-driven computational pipeline with model order reduction for industrial and applied mathematics. *Special Volume ECMI*, in press (2020).

[3] N. Demo, M. Tezzele, and G. Rozza. A non-intrusive approach for reconstruction of POD modal coefficients through active subspaces. *Comptes Rendus Mécanique de l'Académie des Sciences, DataBEST 2019 Special Issue* 347(11):873–881 (2019).

[4] M. Tezzele, F. Salmoiraghi, A. Mola, and G. Rozza. Dimension reduction in heterogeneous parametric spaces with application to naval engineering shape design problems. *Advanced Modeling and Simulation in Engineering Sciences* 5(1):25 (2018).

[5] N. Demo, M. Tezzele, G. Gustin, G. Lavini, and G. Rozza. Shape optimization by means of proper orthogonal decomposition and dynamic mode decomposition. *In Technology and Science for the Ships of the Future: Proceedings of NAV 2018: 19th International Conference on Ship & Maritime Research* 212–219. IOS Press (2018).

[6] F. Romor, M. Tezzele, A. Lario, and G. Rozza. Kernel-based Active Subspaces with application to CFD problems using Discontinuous Galerkin method. Submitted (2020).

[7] N. Demo, G. Ortali, G. Gustin, G. Rozza, and G. Lavini. An efficient computational framework for naval shape design and optimization problems by means of data-driven reduced order modeling techniques. Submitted (2020).