SISSA mathLab naval and nautical engineering main references and open source software

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In the following a comprehensive list of the SISSA mathLab publications in the naval and nautical engineering fields together with a brief introduction of each one of them. The next page presents all the open source software libraries developed by the group in the same context.

A presentation of **different geometrical parameterisation techniques** for naval and nautical geometries and **data-driven model order reduction techniques** such as POD with interpolation and dynamic mode decomposition DMD, for an integrated optimization pipeline:

- M. Tezzele, N. Demo, A. Mola, and G. Rozza. ***An integrated data-driven computational pipeline with model order reduction for industrial and applied mathematics***. *Submitted*, Special Issue ECMI (2018). [arxiv].

Parameter space dimensionality reduction through active subspaces (AS) with heterogeneous parameter for the evaluation of the total drag of a hull advancing in calm water:

- 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, Sep 2018. [arxiv] [doi].

Shape optimization of the bulbous bow using OpenFOAM solver, free form deformation for the geometrical parameterisation, DMD to accelerate the single simulation, and POD with interpolation to construct the surrogate model to optimize:

- 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, pages 212–219. IOS Press, 2018. [arxiv] [doi].

Few contributions that employ AS to assess che parameter influence on the target functions and **reduce the dimension of the parameter space**:

- M. Tezzele, N. Demo, and G. Rozza. ***Shape Optimization through Proper Orthogonal Decomposition with Interpolation and Dynamic Mode Decomposition Enhanced by Active Subspaces.*** In The VIII International Conference on Computational Methods in Marine Engineering, pages 122–133, 2019. [arxiv] [doi].
- A. Mola, M. Tezzele, M. Gadalla, F. Valdenazzi, D.Grassi, R. Padovan, and G. Rozza. ***Efficient Reduction in Shape Parameter Space Dimension for Ship Propeller Blade Design***. In The VIII International Conference on Computational Methods in Marine Engineering, pages 201–212, 2019. [doi].
- M. Tezzele, N. Demo, M. Gadalla, A. Mola, and G. Rozza. ***Model order reduction by means of active subspaces and dynamic mode decomposition for parametric hull shape design hydrodynamics***. In Technology and Science for the Ships of the Future: Proceedings of NAV

2018: 19th International Conference on Ship & Maritime Research, pages 569–576. IOS Press, 2018. [arxiv] [doi].

- N. Demo, M. Tezzele, A. Mola, and G. Rozza. ***An efficient shape parametrisation by free-form deformation enhanced by active subspace for hull hydrodynamic ship design problems in open source environment***. In The 28th International Ocean and Polar Engineering Conference, 2018. [arxiv].

Reduction of both the geometries and the output fields, particularly suited for cases where we do not know the actual geometrical parameters:

- N. Demo, M. Tezzele, A. Mola, and G. Rozza. ***A Complete Data-Driven Framework for the Efficient Solution of Parametric Shape Design and Optimization in Naval Engineering Problems.*** In The VIII International Conference on Computational Methods in Marine Engineering, pages 111–121, 2019. [arxiv] [doi].

Graph theory applied to the modelization of onboard plants in the context of the new regulation for the Safe Return to Port:

- D. Cangelosi, A. Bonvicini, M. Nardo, A. Mola, A. Marchese, M. Tezzele, and G. Rozza. *SRtP 2.0 — The Evolution of the Safe Return to Port Concept.* In Technology and Science for the Ships of the Future: Proceedings of NAV 2018: 19th International Conference on Ship & Maritime Research, pages 665–672. IOS Press, 2018. [doi].

SISSA mathLab Open Source Software

The complete list of SISSA mathLab software is available on GitHub and on SISSA mathLab website, here we present the most interesting ones from a naval engineering point of view.

PyGeM (Python Geometrical Morphing) is a package that allows you to deform a given geometry or mesh with different deformation techniques such as Free Form Deformation, Radial Basis Functions and Inverse Distance Weighting. [github] [SISSA mathLab].

- F. Salmoiraghi, A. Scardigli, H. Telib, and G. Rozza, ***Free Form Deformation, mesh morphing and reduced order methods: enablers for efficient aerodynamic shape optimization,*** Int. J. CFD, 2018 [arxiv].

EZyRB (Easy Reduced Basis method) is a package to perform non-intrusive model order reduction based on Proper Orthogonal Decomposition. [github] [SISSA mathLab].

- N. Demo, M. Tezzele, and G. Rozza. EZyRB: ***Easy Reduced Basis method.*** The Journal of Open Source Software, 3(24):661, 2018. [doi].

PyDMD is a package that uses Dynamic Mode Decomposition for a data-driven model simplification based on spatiotemporal coherent structures. [github] [SISSA mathLab].

- N. Demo, M. Tezzele, and G. Rozza. ***PyDMD: Python Dynamic Mode Decomposition.*** The Journal of Open Source Software, 3(22):530, 2018. [doi].

ITHACA-FV is an implementation in OpenFOAM of several reduced order modelling techniques. [github] [SISSA mathLab].

- Stabile G, Rozza G. ***Finite volume POD-Galerkin stabilised reduced order methods for the parametrised incompressible Navier–Stokes equations.*** Computers & Fluids. 2018. [doi] [arxiv].

BladeX (Python Blade Deformation) is a Python package for geometrical parametrization and bottom-up construction of propeller blades. It allows to generate and deform a blade based on the radial distribution of its parameters. [github].

GRAPE (GRAph Parallel Environment) is a Python package that takes advantage of Graph Theory into a *High Performance Computing* (HPC) environment to develope a screening tool aimed at studying the effect of different kinds of perturbations in interconnected systems, such as industrial plants. [github].

Projects

IRONTH (FINCANTIERI PHD GRANT) The aim of the project, which is based on a PhD grant, is the structural optimization of a naval hull during the design step through parametric techniques and computational reduction.

SRtP (CETENA)
Collaboration with CETENA (FINCANTIERI group) in the framework of the master in High Performance Computing SISSA-ICTP for the development of numerical modelling of onboard plants of cruise ships in the framework of the new Safe Return to Port (SRtP) regulations.

SOPHYA
SOPHYA project aims at studying the seakeeping of planing hull yachts, improving their performance in rough sea and therefore achieving better comfort on board. The tools employed involve advanced numerical analysis and computational fluid dynamics simulations, reduced order modelling and sophisticated geometric parameterisation techniques.

PRELICA
The aim of the PRELICA project is an accurate prevision of the hydroacoustic emissions of a propeller. This is achieved by using potential methods, RANS and LES, and advanced numerical analysis techniques for model order reduction and geometric parameterisation.

FINCANTIERI HULL SHAPE
The aim of the project is the shape optimization of a naval hull through parametric techniques deforming the bow and the stern. The hull shape has to be evaluated both in calm sea and rough sea conditions.

UBE
The project investigates digital simulation methods for the state of exhaust emission particles, from the engine to detachment from the hull, and then tries different geometries and virtual hydro-aerodynamic appendices and, finally, define the optimal geometries for the exhaust manifold for the purposes of hydrodynamic and environmental emissions efficiency.

UBE2
The project aims to understand the vibratory phenomenon occurring on a planing hull. A new design method will be developed in order to mitigate (or even prevent) vibrations on board, by individuating a small set of design parameters and the relative admissibility thresholds.