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

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May 2019

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:


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:


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:


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


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


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

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]


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


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


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


**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 develop 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.