COMPANY
Ficantieri

RESEARCH CENTRE
SISSA mathLab group

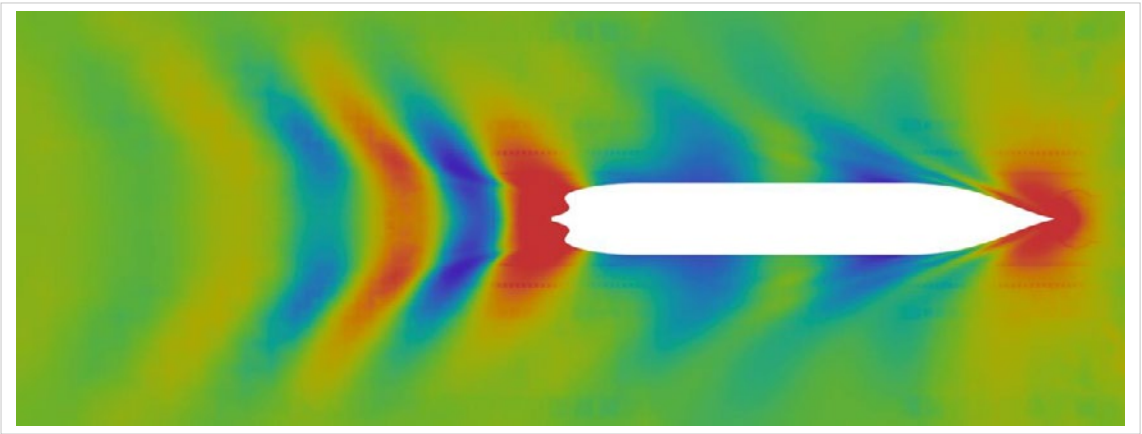
PRODUCTIVE SECTOR
Mechanics and Mechatronics

Digital Twin

SS_003_2019

DATA DRIVEN SHAPE OPTIMIZATION SYSTEM

An efficient computational pipeline to reduce the ship resistance in calm water scenario.



Computational fluid dynamics simulation of a cruise ship advancing in calm water.

PROBLEM DESCRIPTION

Fincantieri S.p.A., one of the largest shipbuilding companies in the world, was interested in an efficient shape optimization framework to reduce the hydrodinamic ship resistance. The aim is to achieve a remarkable reduction of the fuel consumption in the new cruise ships.

CHALLENGES AND GOALS

- ✔ Obtain a parametric formulation of the original shape.
- ✔ Increase the efficiency through the exploitation of model order reduction techniques.
- ✔ Integrate all the tools to provide a black-box framework to optimize a certain objective function.

MATHEMATICAL AND COMPUTATIONAL METHODS

The resulting optimization framework consists in a numerical pipeline composed by several tools.

- ✔ Free-form deformation is applied to hull shape to deform the original ship.
- ✔ The finite volume approach allows to simulate the turbulent flow. We collect the high-fidelity solutions database for some properly chosen configurations.
- ✔ We use dynamic mode decomposition to accelerate a single numerical simulation, thanks to its capability to individuate the system dynamics.
- ✔ Proper orthogonal decomposition with interpolation is applied to efficiently compute the solution of a parametric partial differential equations, exploiting the solutions database pre-computed.

Finally, we adopt a global optimization algorithm over the reduced space in order to converge to the optimal shape.

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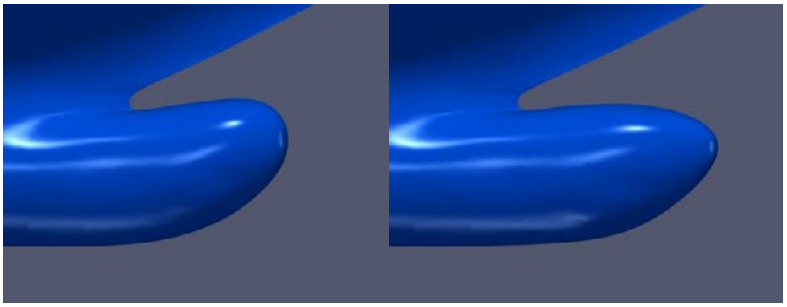
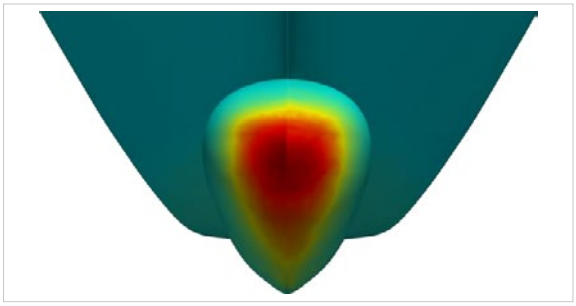


Example of pipeline application: the original bulb (left) and the optimized one (right).



Visualisation of the total drag: on the right the output from reduced order model, on the left the output from full-order model.

RESULTS AND BENEFITS

During the collaboration, three open source packages containing the adopted methodologies, PyDMD, EZyRB and PyGeM, have been developed and they have been integrated to build the pipeline. The resulted optimization system has been tested to optimize the bulbous bow and the stern of (existing and prototype) cruise ships: the total drag of the ship has been reduced and the over-all execution time, respect to conventional ptimization frameworks, has drastically shortned.

The company has an efficient and integrated data-driven framework to design, optimize and validate the hull shape.

Moreover the modularity of the pipeline allows to replace the components or extend them.

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Fincantieri S.p.A.
Italian company leader in cruise ship manufacturing.