MSc. Thesis Proposal

Title: Prediction model for ship propeller performance using machine learning

Supervisors

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Introduction

Motivation

Ship propellers sections are like foils and rudders, but with a much smaller span-to-chord ratio due to the limitation of the diameter and the danger of cavitation. The small span-to-chord is one of the reasons that make the propeller flows complex and with that, simple 2D models are quite inaccurate. 3D models are therefore developed to calculate and analyse if the propeller achieves the required thrust, the expected open-water efficiency, the pressure distribution to analyse the risk of cavitation and the possible vibration induced by the forces and momentum of the propeller rotation.

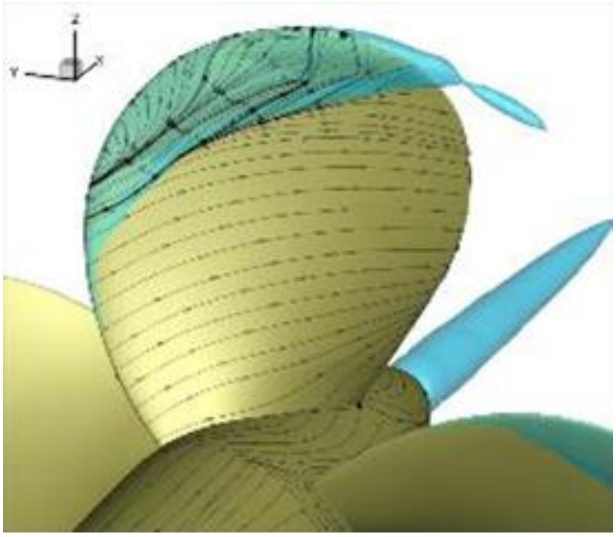

Figure 1 - Ship propeller cavitation CFD simulation

To calculate these characteristics, the most common methods are the lifting surface method, the panel method and the RANSE method. The latter is the most completed method, capturing viscous effects and the flow near hub and tip propeller, but with a high computational and grid generation cost.

Existing work

Propeller development has been studied for more than a century, with different methods to verify their thrust, efficiency, pressure distribution, cavitation and noise, many of them expensive and time consuming. The GCNN concept is quite new (2014) and has recently started to be used as an optimisation method for aerodynamic and hydrodynamic developments, with only few studies developed and published in the area. This proposal aims to verify how powerful this machine learning method can be for propeller analysis and optimization.

Objectives

The objective of this thesis is to train, evaluate and optimize an ML algorithm capable of predict the efficiency of a ship propeller, changing the diameter, boss diameter and propeller pitch, using Panel Methods or RANS calculations as input data to calibrate and train the ML model. The model will be trained to predict the values of the thrust coefficient, torque coefficient and open-water efficiency, also, the field quantities, as the axial velocity in the propeller wake and the pressure coefficient on the propeller blades.

The tasks are as follows:

- Study Geodesic Convolutional Neural Networks (GCNN) [1], [2] model and similar techniques for making forces, moments, and flow-field predictions of pressure and wake velocity using propellers and others solid-fluid interaction [3], [4].
- Study the usage of PROPAN [5].
- Study the usage of ReFRESCO [6].
- Calculate with PROPAN and ReFRESCO an existing propeller geometry, like the B-series of Wageningen. Compare with experimental data (model-scale), or just do full-scale.
- Postprocess the data from the numerical simulations.
- Pre-process database for ML method.
- Train and validate the GCNN prediction model.
- Test the algorithm with results in the training, and outside the training data.

The student should provide a working algorithm with its final characteristics and metrics, a pre-processing method, and recommendation for future work.

Requisites

Applicants must have:

- General knowledge of Artificial Intelligence
- General knowledge of CFD
- Coding experience with Python or similar

Good to have:

- Linux experience
- LateX experience
- Git experience

Location

blueOASIS (www.blueoasis.pt) Edificio D.Pedro, Quinta da Fonte, R. Malhões, 2770-071 Lisboa The student is invited to join the team in the office when the supervisor is present (at least three days per week).

Companies Involved

blueOASIS is a young team with more than 45 years of combined knowledge and experience on Aerospace, Mechanical, Naval and Maritime engineering. The multicultural and multidisciplinary team is committed to make our oceans safer and greener, using state of the art numerical and data science tools. BlueOASIS focuses on renewable energies, ocean cleaning, decarbonization, sustainable offshore structures and green ships optimization.

Bibliography

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[5] J. Baltazar, “PROPAN.” https://www.researchgate.net/project/PROPAN-potential-flow-code-for-foils-and-rotors

[6] D. Rijpkema and G. Vaz, “Viscous flow computations on propulsors: Verification, validation and scale effects,” *RINA, R. Inst. Nav. Archit. - Dev. Mar. CFD, Pap.*, pp. 35–47, 2011.