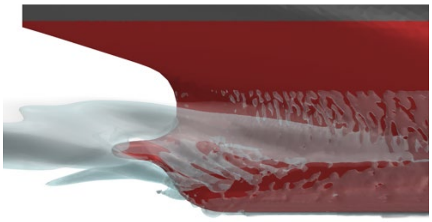
Machine Learning for Prediction of Ship Wake in Waves

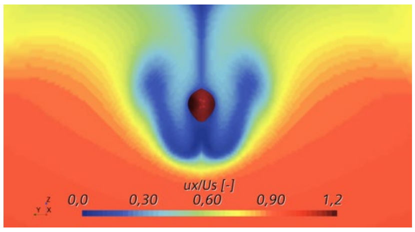
Background and motivation

When sailing in harsh sea environments, a ship's fuel consumption and air emission can be easily increased by more than 100% due to reduced propulsive efficiency. The ship wake (flow into the propeller) is one of the significant factors that directly determine the ship propulsive efficiency. Therefore, it is essential to accurately predict the wake field under various operational conditions (e.g., varying ship speed and encountered waves) to have reliable prediction of ship energy performance at sea and develop energy efficiency measures. This in turn can help to reduce a ship's fuel consumption and consequently air and water emissions.

A ship wake can be obtained either through experimental measurements or computational methods. However, due to high cost and sophistication of experiments for obtaining the wake the computational approach is often preferred by the industry. Thanks to the development of modern computational methods during the recent years, naval architects have been able to explore the interaction effects more in detail and enhance their designs. A computational grid consists of several subdomains (cell). The complicated set of non-linear differential equations that we solve for simulating the flow physics are discretized and solved for each of these subdomains. Today, a typical mesh size for resistance prediction in calm water is about 3-6 million cells and in case ship operating in waves or when the flow around the propeller and appendages is also important the mesh size would be around 20-30 million cells. As a result of large number of computational cells required in such simulations, the flow prediction becomes computationally expensive. The computational cost even increases more when the ship wake dynamics in waves is required (instead of steady state calm water wake). A simulation for prediction of the wake dynamics in waves can take more than 7 days on high performance computers (e.g., on 128 computational cores).



Coherent flow structures in the aft part of a hull



Flow into the propeller (wake)

Objectives and goals

Machine Learning (ML) Methods can be efficient tools for reducing the computational costs associated with ship wake prediction. This master thesis will include one or several of the following tasks:

- Application of Dynamic Mode Decomposition (DMD) technique to break down the complex dynamics of the wake into coherent flow structures for characterization of physical mechanisms in flow.
- Investigate the feasibility of employing ML for ship wake prediction.
- Finally, the obtained propulsive efficiency will be integrated into a ship's performance model to estimate the ship's fuel consumption and air emission at actual sailing environments.

Contact persons:

This master thesis project is a joint supervision project between division of Marine Technology and division of Fluid Dynamics at the Department of Mechanics and Maritime Sciences.

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