TUHH
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TUHH · M-10 · Am Schwarzenberg-Campus 4C · D-21073 Hamburg

MASTER THESIS

# Predicting Ship structural responses to Enable Autonomous Shipping: Fluid-Structure-Interaction and Machine Learning

Autonomous ships are seen by the maritime industry as key to improve shipping efficiency and safety in the future. The full realization of the benefits of autonomous shipping requires significant developments within ship design, navigation and control systems technology and operational modes combined with the ability to assess and verify the safety and performance in a credible manner. The aim of the work is to develop a digital twin (DT) approach to address one aspect of the very complex overall problem – ship hydrodynamics in waves and the associated structural consequences based on near field information. A one way fluid-structure interaction (FSI) (ANSYS WAVE) will be used to accurately transfer the loads obtained from a hydrodynamic analysis (ANSYS AQWA) to the structural model (ANSYS MECHANICAL). In previous works dealing with DT applications to predict structural responses in wave environments [1] only analytical methods were used to approximate stresses of ship structures. The physical model of this work is based on a Finite Element Analysis of a more detailed ship structure including first and second order structural elements like frames and stiffeners.
The complexity of the targeted physical model hinders the real-time application required by autonomous ships. Machine Learning algorithms enable to perform complex tasks in real time without using explicit instructions or physical models. Thus, it is necessary to create a Machine Learning based DT to predict structural responses in real-time. The results of the physical DT will form the basis for supervised training of the ML DT.

This project is concerned with finding the correlation between wave parameters and structural responses in real time. To accomplish this objective, the work will be divided into the following steps

1) Review and adaptation of an existing ship model in ANSY Mechanical
2) Application of the FSI method ANSYS WAVE
3) Automation of the FSI method ANSYS WAVE
4) Creation of a training/validation data set
5) Review and further development of an existing ML application
6) Prediction of structural responses using ML
7) Comparison of the physical and ML Model

Literature studies of specific topics relevant to the thesis work shall be included.

The work scope may prove to be larger than initially anticipated. Subject to approval from the supervisors, topics may be deleted from the list above or reduced in extent.

In the thesis the candidate shall present his personal contribution to the resolution of problems within the scope of the thesis work.

Theories and conclusions should be based on mathematical derivations and/or logic reasoning identifying the various steps in the deduction.

The candidate should utilise the existing possibilities for obtaining relevant literature.

**Ownership**
According to the current rules, the candidate has the ownership of the thesis. Any use of the thesis has to be approved by TUHH M-10 (or external partner when this applies). TUHH M-10 has the right to use the thesis as if a TUHH M-10 employee carried out the work, if nothing else has been agreed in advance.

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References:
[1] Schirmann, M. L., M. D. Collette, and J. W. Gose (2018b), Ship Motion and Fatigue Damage Estimation via a Digital Twin, Life-Cycle Analysis and Assessment in Civil Engineering: Towards an Integrated Vision, edited by R. Caspeele, L. Taerwe, and D. M. Frangopol, pp. 2075–2082, Taylor & Francis Group, London, Ghent, Belgium