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The Influence of Seaway Parameters on the Generalizability of a Force-Correcting Machine Learning Method

Kyle E. Marlantes[1,*], Piotr J. Bandyk[2] and Kevin J. Maki[1]

[1] Department of Naval Architecture and Marine Engineering
University of Michigan, 48109, Ann Arbor, MI, USA

[2] MARIN, USA, Inc.
[*] kylemarl@umich.edu

ABSTRACT

In this work, the force-correcting machine learning method of Marlantes et al. (2024) is utilized as a data-leveraging tool alongside the boundary element code PANShip (van Walree, 2002) to predict the heave, roll, and pitch responses of a Fast Displacement Ship (FDS) in a range of seaways for a region in the North Atlantic. The method is trained using high-fidelity response data from a single seaway, and the trained model is used to make predictions across fourteen different seaways parameterized by a significant wave height H_s and average period T_{01}, as shown in Figure 1. The predictions are validated against known high-fidelity reference data and peak statistics, in the form of the average of the highest 1/10th response peaks, are also provided.

The seaway parameters H_s and T_{01} that correspond to the training point are investigated to identify their influence on the generalizability of the trained model. Specifically, the force-correcting method is trained using high-fidelity responses from different combinations of H_s and T_{01} and then used to make predictions over the range of seaways. For each combination of H_s and T_{01}, the corresponding response predictions are analyzed statistically to discover trends. The statistical properties of the total hydrodynamic forces and moments are also presented and discussed.

The results of this paper make recommendations on the best choice of H_s and T_{01} for training data when generalizability over seaways is desired. Furthermore, the ability of the model to predict infrequent responses, such as slamming events, is considered when such events are not included in the original training data set. Generalizability over seaways is an important characteristic to enable data-driven methods for simulation-based design optimization for marine vehicles, where it may be impractical to sample training data over a wide range of wave conditions or response profiles.

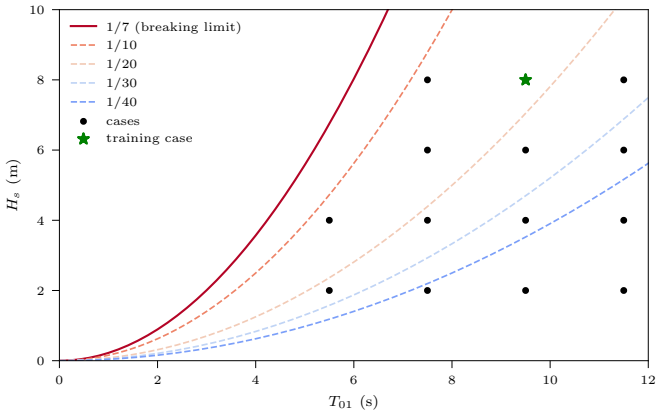

Figure 1: An illustration of fourteen selected seaways for a region in the North Atlantic. A limited set of data from a single seaway, for example indicated by ★, is used for training data and response predictions are made in the remaining seaways.

References

Marlantes, K. E., P. J. Bandyk, and K. J. Maki. Predicting ship responses in different seaways using a generalizable force correcting machine learning method, Ocean Engineering, 312, 2024.

van Walree, F. Development, validation and application of a time domain seakeeping method for high speed craft with a ride control system, in Proceedings of the 24th Symposium on Naval Hydrodynamics, 2002.