XI International Conference on Computational Methods in Marine Engineering

Machine Learning for Ocean Wave Height Estimation

Michael D. Levine[1] and Samuel J. Edwards[1*]

[1] Naval Surface Warfare Center – Carderock Division
9500 MacArthur Blvd, Bethesda, MD 20817, USA

[*] Corresponding Author: samuel.j.edwards33.civ@us.navy.mil

ABSTRACT

Safe operation of a ship requires accounting for ship motion responses in stochastic ocean waves. Excessive ship motions can lead to hazardous and unsafe conditions such as pure loss of stability, surf-ride and broaching (IMO, 2020). Mitigation of these risks can be performed through selection of ship speeds and headings for a given seaway, and avoiding conditions likely to lead to severe motions. Estimation of wave conditions is typically based on weather forecast data. However, significant variability can exist between predicted wave conditions from a general area forecast, and the actual conditions in the local vicinity of the vessel. Additionally, the fidelity of a given weather forecast degrades as a function of time. Alternatively, local conditions can be measured off-board by wave buoys, but this requires deployment and retrieval of sensor hardware as well a transmission and processing of buoy data. By effectively employing the "ship as buoy", on-board measurements of ship motion responses to a seaway can potentially help address estimation of local wave conditions (Nielsen et al., 2023).

A new data-adaptive model is investigated as a prospective capability for estimation of ocean wave height based on ship motions. Long Short-Term Memory (LSTM) neural networks are trained and tested with physics-based Large Amplitude Motion Program (LAMP) simulation data. This approach focuses on prediction of wave height based on simulated 6-DOF ship motion responses. LSTM networks are trained and tested with simulated wave time-series data as the target and motion time-series as inputs. For training data, wave-series are generated based on the Longuet-Higgins model. LAMP simulations and LSTM training are performed over a set of irregular unidirectional wave conditions in Sea States 5 and 6. From initial results, this machine learning approach has the potential to produce results consistent with a physics-based model.

References

IMO "Interim Guidelines on the Second Generation Intact Stability Criteria", MCS.1/Circ. 1627, International Maritime Organization, London, UK`, 2020.I. M. Viola and R. G. J. Flay. Pressure Distribution on Sails Investigated using Three Methods: On-Water Measurements, Wind-Tunnel Measurements, and Computational Fluid Dynamics. In 20th Chesapeake Sailing Yacht Symposium, 2011.

U.D Nielsen., H.B. Bingham., Brodtkorb, A. H., Iseki, T., Jensen, J. J., Mittendorf, M., Mounet, R. E. G., Shao, Y., Storhaug, G., Sørensen, A. J., and Takami, T., (2023). Estimating Waves via Measured Ship Responses. Scientific Reports, Vol. 13