Quantifying Extreme Event Statistics for Ship Motions and Loads Using Low-Fidelity Models and Recurrent Neural Networks

by

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ABSTRACT

Ship operators and designers alike use ship motion simulation software to predict ship responses in irregular ocean waves, along with the statistics of extreme events. Ship operators rely on precalculated polar plots during heavy seas to select speeds and headings that will protect the ship and crew from dangerously extreme pitch and roll motion. Ship designers use simulations over thousands of operational hours to predict the effects of vertical bending moment on the structural integrity of the ship. This thesis considers two simulation methods that fulfill these needs, Large Amplitude Motion Program (LAMP) and SimpleCode. LAMP is higher-fidelity but computationally expensive, while SimpleCode uses a reduced order model but is orders of magnitude faster. This thesis investigates the use of machine learning, specifically a Long Short-Term Memory (LSTM) artificial neural network, to augment SimpleCode, such that the combined results are high fidelity, akin to LAMP. The LSTM proves effective in creating a map directly from the output of SimpleCode to the output of LAMP, without significant computational overhead. The LSTM's performance over large sea state domains, including unimodal and bimodal seas, is studied. The distribution of motion peaks predicted by the LSTM over thousands of operational hours in a given sea state is shown to closely resemble that of LAMP. The time savings of using the LSTM approach are quantified and found to provide significant advantage in multiple applications.

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