Investigating the Use of Inductive Transfer Learning and RNN to Quantify Extreme Event Statistics of Ship Motions

by

Jarod Kramer

Submitted to the Department of Mechanical Engineering

and

and the System Design and Management Program
on May 12, 2023, in partial fulfillment of the
requirements for the degrees of

Naval Engineer
and
Master of Science in Engineering and Management

Abstract

Ship motion software has been a critical tool for designers to study the extreme responses of ships in irregular waves. These studies and simulations often take thousands of hours to predict and analyze the ship's motion. Simulation results are often imperative to ensure the development of accurate operational guidance, typically in the form of plots, advising the crew on safe course and speed combinations to avoid dangerous roll and pitch motions. Two programs in use by the Navy to fill this need are the fast, lower-fidelity SimpleCode program and the slower, higher-fidelity Large Amplitude Motion Program (LAMP). Previous efforts have developed a framework to leverage machine learning through a Long Short-Term Memory (LSTM) network architecture to augment the SimpleCode program by mapping its ship motion output to the more accurate LAMP output without adding significant computational overhead. This process of using an LSTM neural network to improve the SimpleCode output provides the opportunity to supply predictions and guidance to the crew in real-time. However, the limits of this mapping across various sea domains still need to be discovered. By investigating these limits, a more generalized LSTM can be realized through inductive transfer learning and a model agnostic meta-learning approach, one that leverages the training of previous networks to augment SimpleCode across a broader range of seas or produce more accurate results on a narrow set of sea conditions after very few training samples.

Thesis Supervisor: Themistoklis Sapsis
Title: Professor of Mechanical Engineering