PREDICTION OF MOTIONS, MOORING TENSIONS AND STRUCTURAL LOADS IN FLOATING WIND TURBINES USING ARTIFICIAL INTELLIGENCE MODELS

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ABSTRACT

Accurate prediction of the dynamic responses of Floating Wind Turbines (FWTs) is essential for optimizing their design and operation, especially as offshore wind farms are increasingly deployed in deeper waters. This complexity necessitates advanced techniques to handle the intricate motions, loads, and deformations experienced by these structures. Artificial intelligence (AI) methodologies, particularly those based on machine learning, provide a promising solution to these challenges.

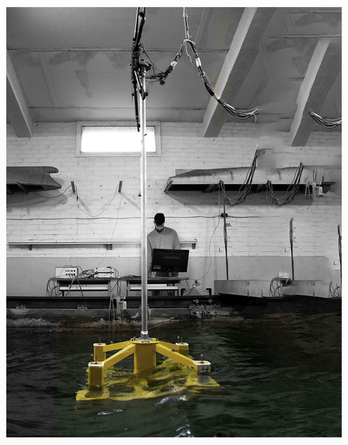
By employing AI techniques that utilize real data from experimental tests and numerical modeling, we can predict the dynamic responses of FWTs, including motions, aerodynamic deformations, and mooring loads, with high accuracy. These advanced predictive capabilities are crucial for reducing platform motions and mooring line loads, thereby enhancing the efficiency and reliability of offshore wind turbines.

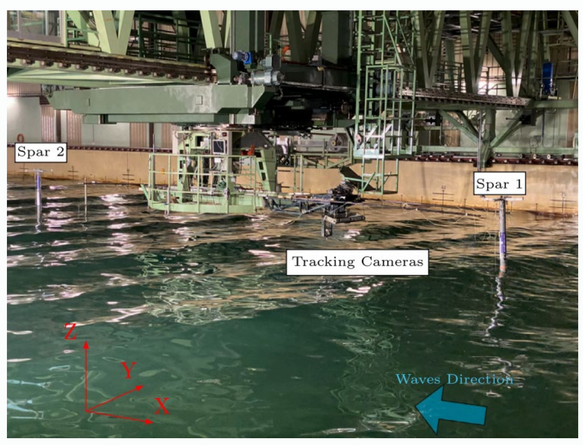
OBJETIVES

"Employ artificial intelligence methodologies to predict the responses of FWTs (in several dimensions including motions, loads and deformations of aerodynamic elements, mooring loads, etc.). These techniques will be based on real data obtained from experimental tests and numerical modeling"

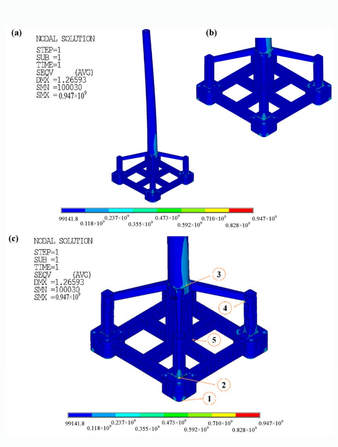
METHODOLOGY

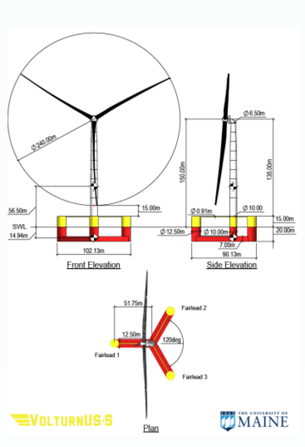
Experimental Campaigns



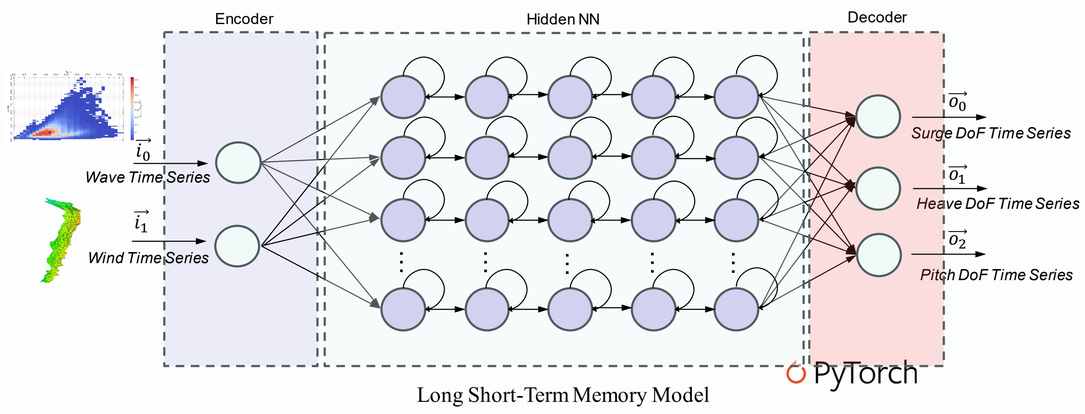


Case Study





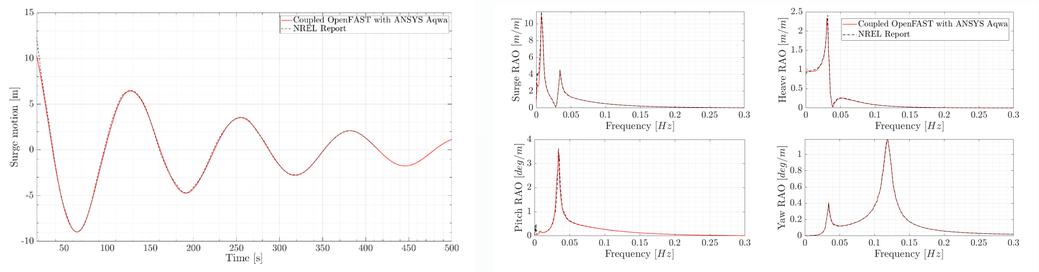
LSTM NN Model



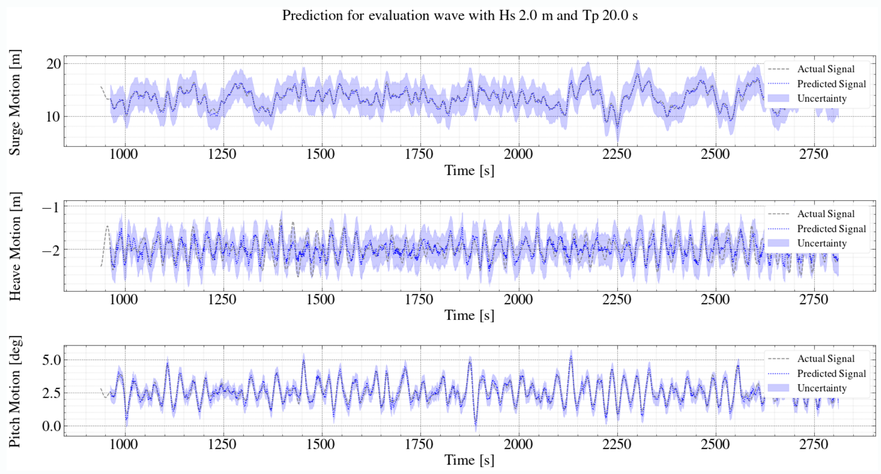
Long Short-Term Memory Model

RESULTS

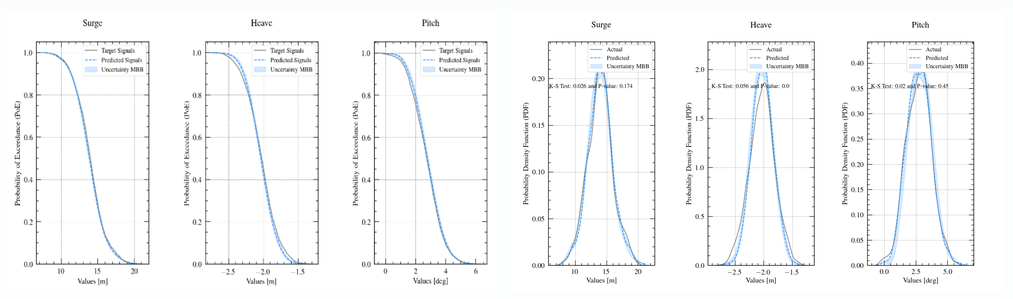
Data-Set Generation and Numerical Model Validation

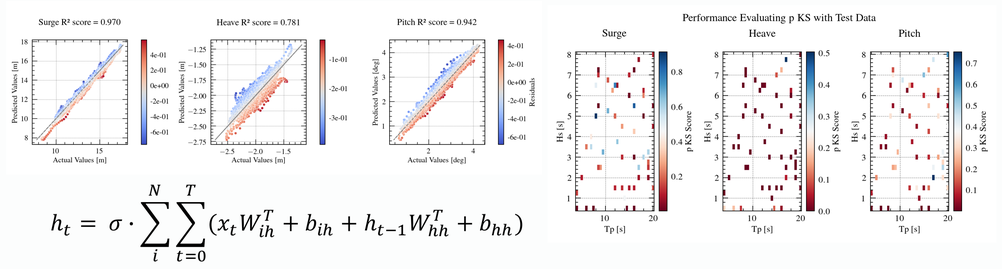


Testing Prediction Motions with Neural Network



Neural Network Accuracy Evaluation





$$h_t = \sigma \cdot \sum_{i}^{N} \sum_{t=0}^{T} (x_t W_{ih}^T + b_{ih} + h_{t-1} W_{hh}^T + b_{hh})$$

CONCLUSIONS AND ONGOING WORK

- Develop a Long Short-Term Memory (LSTM) Neural Network model suitable to predict all motions and fairlead tensions time series using waves and wind time series as input.
- (*Ongoing*) Evaluation of the accuracy and reliability of the model.
- (Ongoing) Training with fully coupled simulations results.

PUBLICATIONS AND CONFERENCES

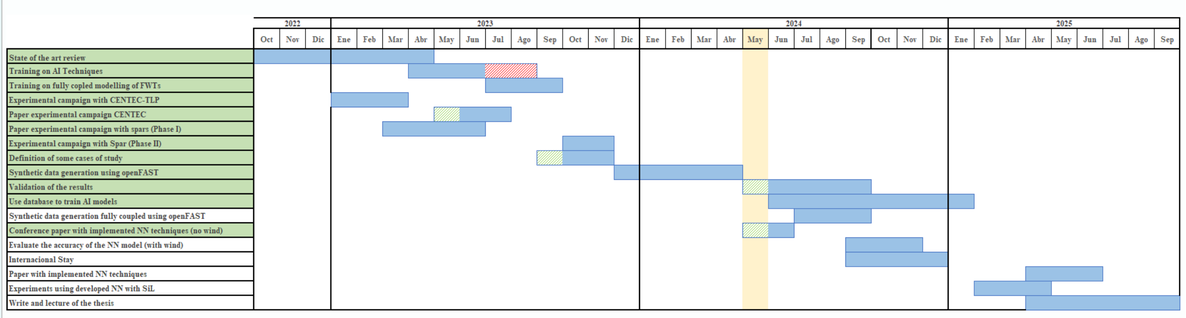
[1] Hmedi, Mohamad, Emre Uzunoglu, **Antonio MEDINA-MANUEL**, Jordi Mas-Soler, Felipe Vittori, Oscar Pires, José Azcona, Antonio Souto-Iglesias, and C. Guedes Soares. "Experimental Analysis of CENTEC-TLP Self-Stable Platform with a 10 MW Turbine". Journal of Marine Science and Engineering. **(Q1)**

[2] Tomas Lopez-Olocco**,** Guodong Liang, **Antonio MEDINA-MANUEL**, Leandro Saavedra Ynocente, Zhiyu Jiang, Antonio Souto-Iglesias **"**Experimental comparison of a dual-spar floating wind farm with shared mooring against a single floating wind turbine under wave conditions". Journal of Engineering Structures **(Q1)**

[3] Guodong Liang, Tomas Lopez-Olocco**, Antonio MEDINA-MANUEL**, Leandro Saavedra Ynocente, Zhiyu Jiang, Antonio Souto-Iglesias **"**Experimental investigation of two shared mooring configurations for a dual-spar floating offshore wind farm in irregular waves". Journal of Marine Structures **(Q1)**

Presentations in internacional conferences: MARTECH2024, ENERMAR2024

PLANNING



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[A] Browning, J., J. Jonkman, A. Robertson, & A. Goupee (2014)**.** Calibration and validation of a spar-type floating offshore wind turbine model using the fast dynamic simulation tool. Journal of Physics: Conference Series 555, 012015.

[B] Hochreiter, S. & J. Schmidhuber (1997)**.** Long short-term memory. Neural computation 9, 1735–80.

[C] Silva, K. M. & K. J. Maki (2024). Implementation of the critical wave groups method with computational fluid dynamics and neural networks. Ocean Engineering 292, 116468.