Prediction of Mooring Tension of a Floating Wind Turbine Using Motion Sensors and Neural Networks

Mohammad Arif Payenda[1], Shuaishuai Wang[2], Andreas Prinz[1], Mohammad Ali Hussiny[3], Zhiyu Jiang[4]
[1]Department of Information and Communication Technology, University of Agder, N-4898 Grimstad, Norway
[2]Department of Marine Technology, Norwegian University of Science and Technology, Trondheim, Norway
[3]Department of Computer Sciences, Oslo Metropolitan University, 0130 Oslo, Norway
[4]Department of Engineering Sciences, University of Agder, N-4898 Grimstad, Norway

1 Abstract

The study evaluates nacelle motion accelerometers in six degrees of freedom under various load conditions (rated, cut-out, parked) to monitor floating wind turbine movements and vibrations [1].
Monitoring nacelle motion is essential for assessing structural health and enabling dynamic control to optimize turbine performance and stability [2].
A hybrid CNN-BiLSTM model was proposed to enhance prediction accuracy by combining the strengths of Convolutional Neural Networks (CNN) and Bidirectional Long Short-Term Memory (BiLSTM) networks.

2 Introduction and motivation

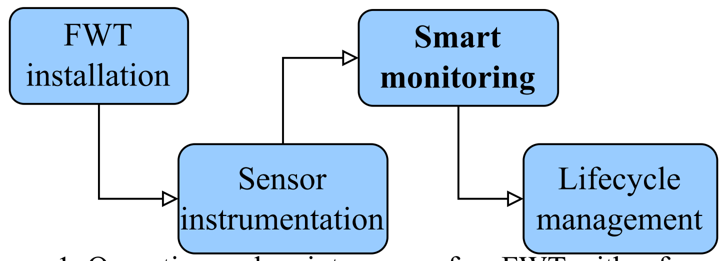


Figure 1. Operation and maintenance of an FWT with a focus on structural health monitoring.

- Understanding the performance of floater motion accelerometers in six degrees of freedom under various load conditions.
- Comparing the performance of deep learning algorithms for predicting mooring line tensions using sensor data.

3 FWT numerical dataset

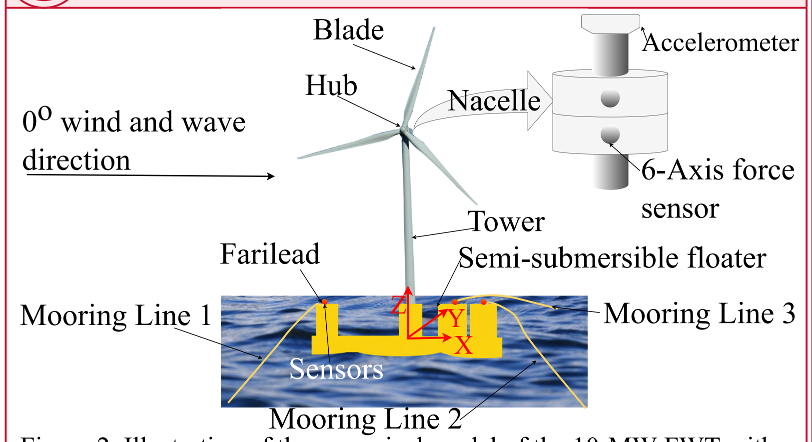


Figure 2. Illustration of the numerical model of the 10-MW FWT with coordinate system.

4 Deep learning model development

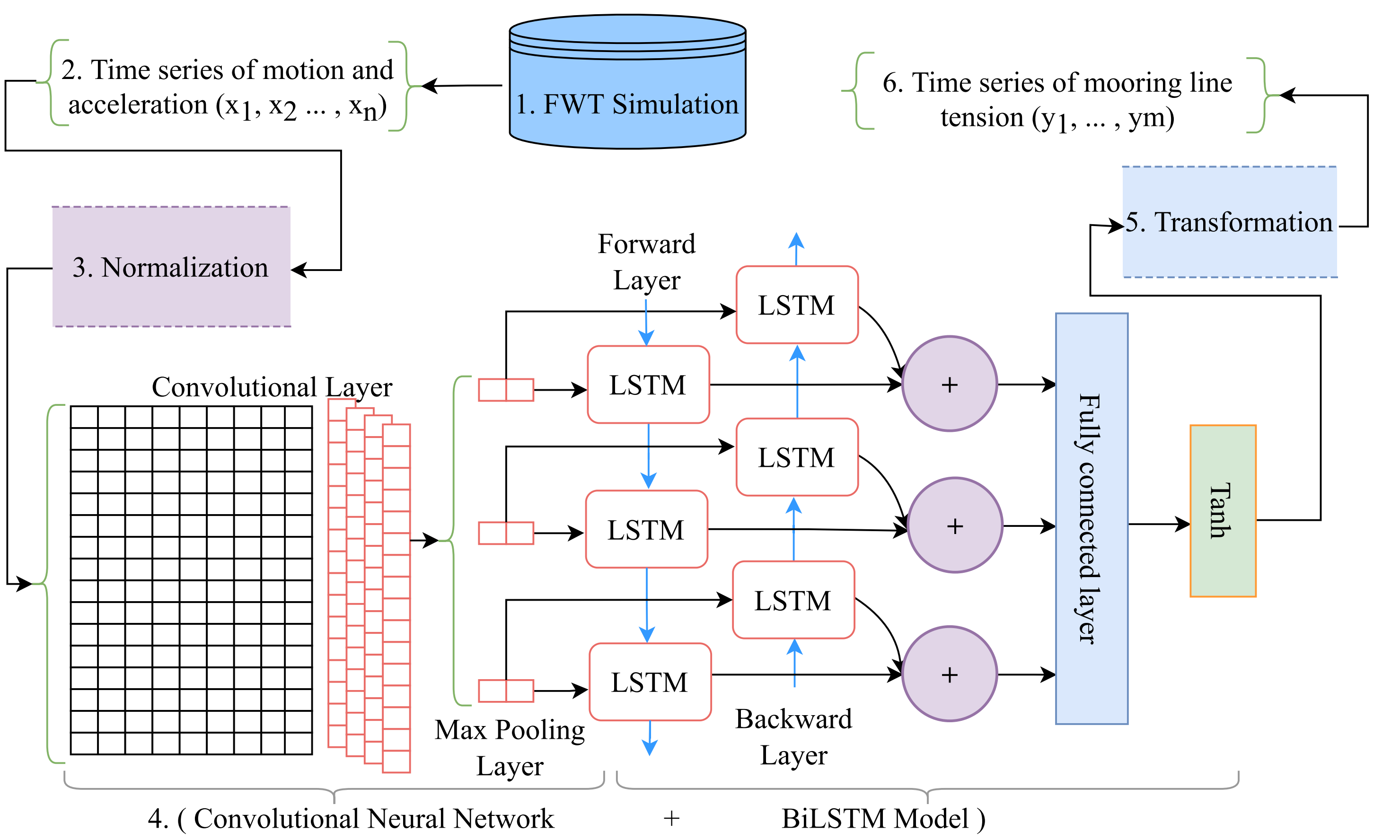
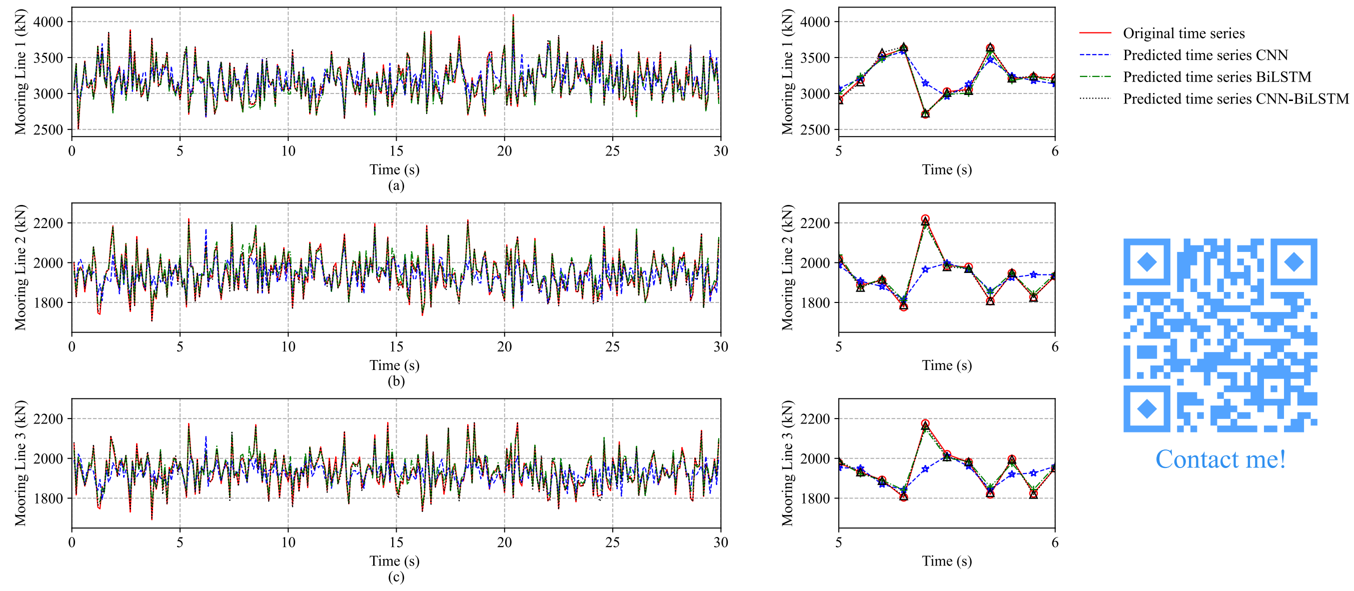


Figure 3. The proposed approach (CNN-BiLSTM)

5 Results



Contact me!

Figure 4: Selected time series of mooring line tensions in LC1, (a) line 1, (b) line 2, and (c) line 3. Original data versus predicted data using CNN, BiLSTM, and CNN-BiLSTM models, with X, Y, and Z acceleration.

Table 1. List of performance metrics averaged across three mooring lines with X, Y, and Z acceleration for the CNN, BiLSTM, and CNN-BiLSTM models under LC1

Load Case	Model	MSE	MAE	RMSE	R^2
	CNN	0.0258	0.01211	0.1606	0.7568
LC1	BiLSTM	0.0031	0.0438	0.0558	0.9770
	CNN-BiLSTM	0.0005	0.0173	0.0224	0.9958

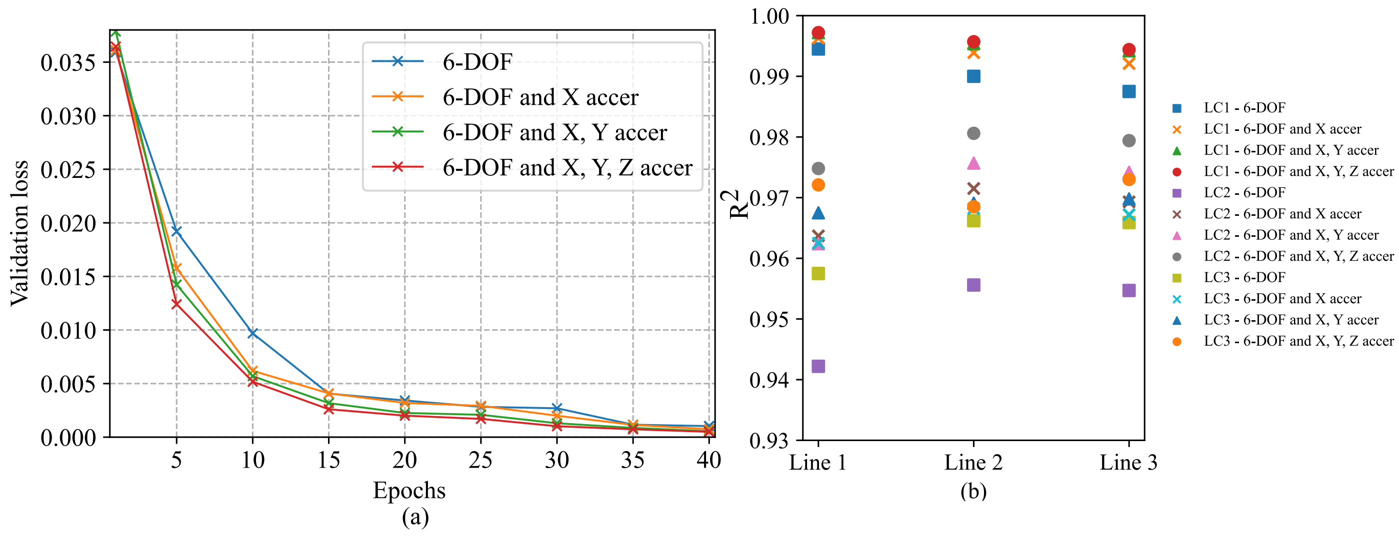


Figure 5. (a) validation loss for LC1 in the proposed model, (b) R^2 values for various load cases, including LC1, LC2, and LC3.

6 Conclusion and key findings

1. A novel hybrid model for predicting mooring line forces indroduced, CNN-BiLSTM.
2. Adding the surge motion accelerometer has the greatest effect on predicting mooring tensions, with an R^2 value of 0.9941.
3. Adding sway motion the R^2 value is 0.9956, representing a 0.15% increase from the surge motion
4. Adding heave motion, the R^2 value is 0.9958, representing a 0.17% increase from the surge motion accelerometer.

7 References

[1] Payenda, Mohammad Arif, et al. "Prediction of mooring dynamics for a semi-submersible floating wind turbine with recurrent neural network models." Ocean Engineering 313 (2024): 119490.

[2] Wang, Shuaishuai, et al. "Design, local structural stress, and global dynamic response analysis of a steel semi-submersible hull for a 10-MW floating wind turbine." Engineering Structures 291 (2023): 116474.