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Load-measurement method for floating offshore wind turbines based on a long short-term memory (LSTM) neural network

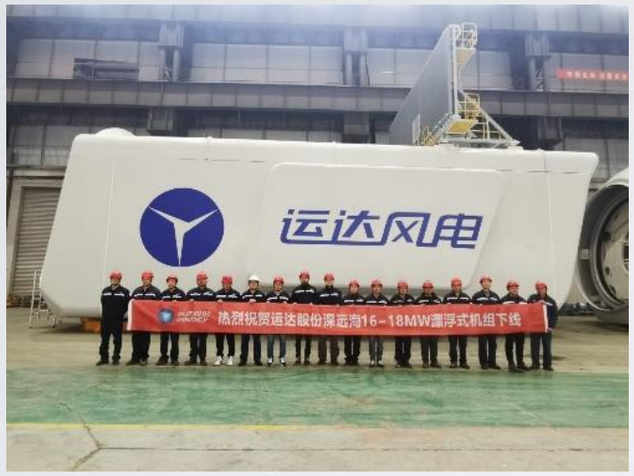
Key words:

Floating offshore wind turbine (FOWT); Long short-term memory (LSTM) neural network; Machine learning technique; Load measurement; Hybrid-scale model test



Motivation

Large scale



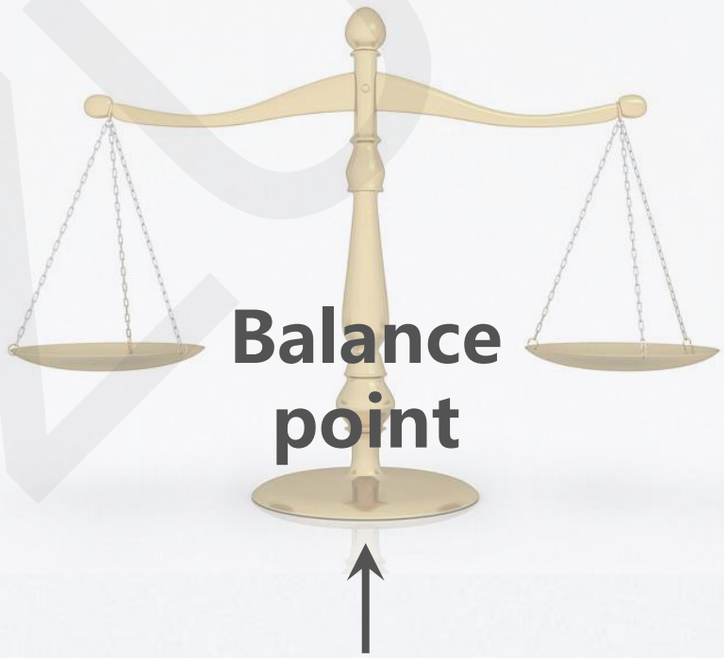
16 MW wind turbine

Commercialization



Hywind Tampen

Safety



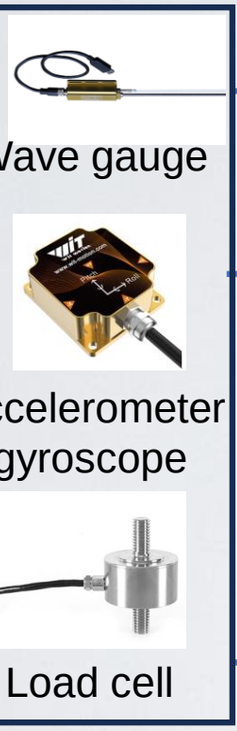
Cost

Load data of the turbine in real sea states

Method

Load measurement method for FOWT

Sensor system



Wave elevation

Displacement velocity acceleration

Inertial load $F_{Inertia}$

Mooring tension F_{Moor}

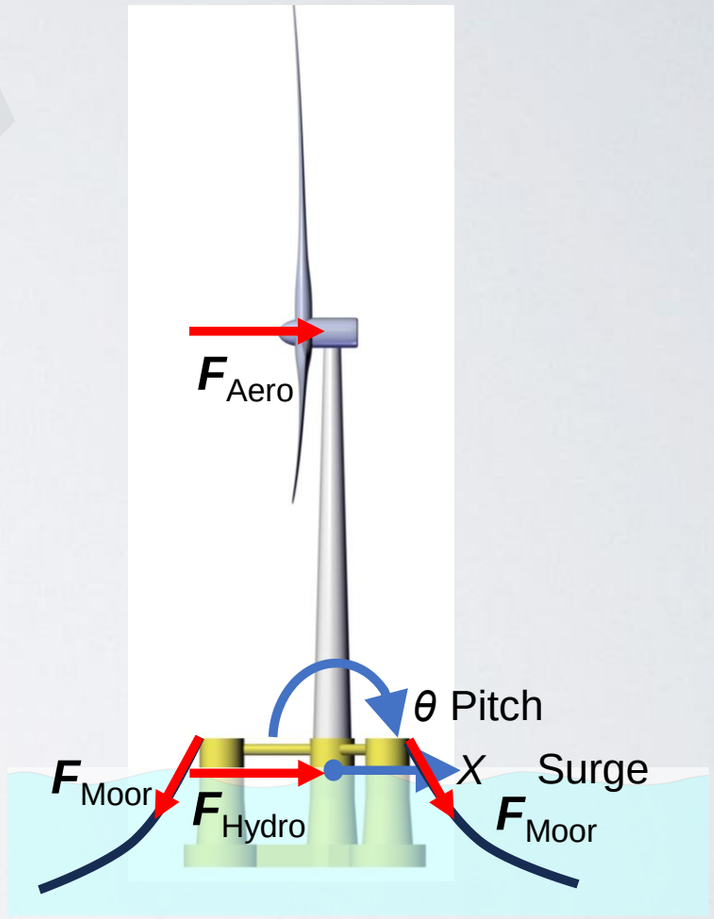
LSTM neural network model

Hydrodynamic load F_{Hydro}

D'Alembert principle

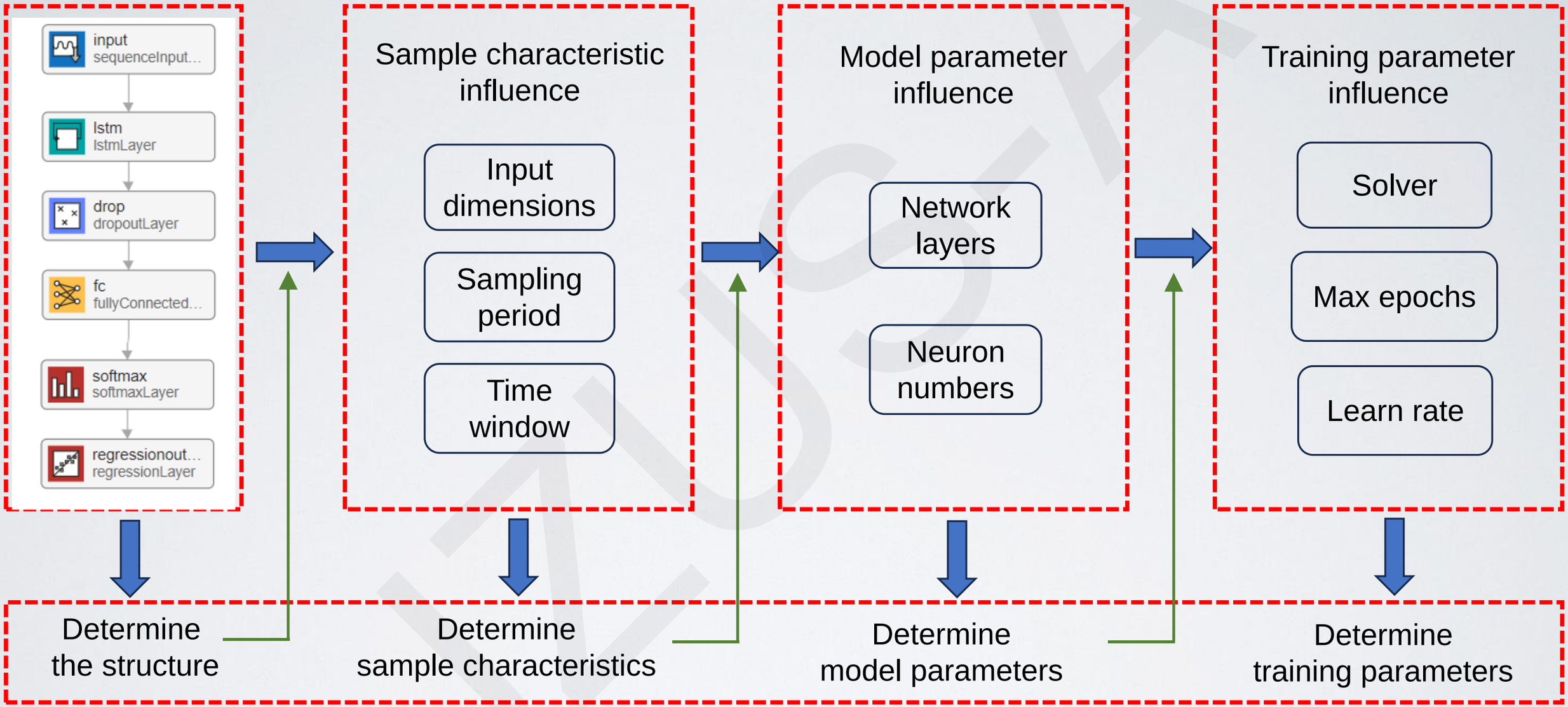
Aerodynamic load F_{Aero}

$$F_{Aero} = -(F_{Hydro} + F_{Moor} + F_{Inertia})$$



Aerodynamic Load was calculated indirectly by mature sensors

Model training



Optimal LSTM model was determined step by step

Experimental setup





Thrust



Wave elevation



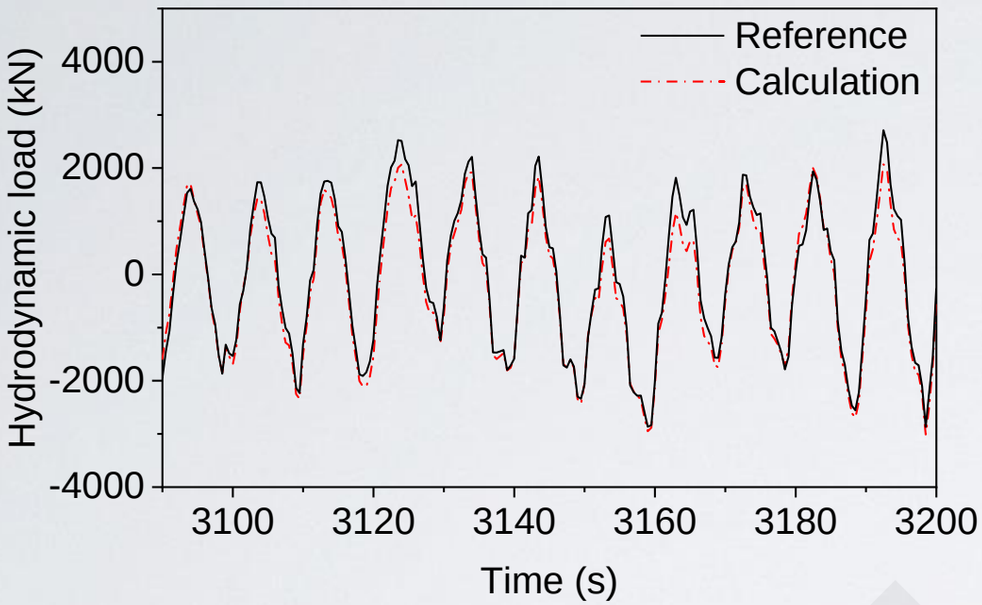
Mooring tension
Mooring angle

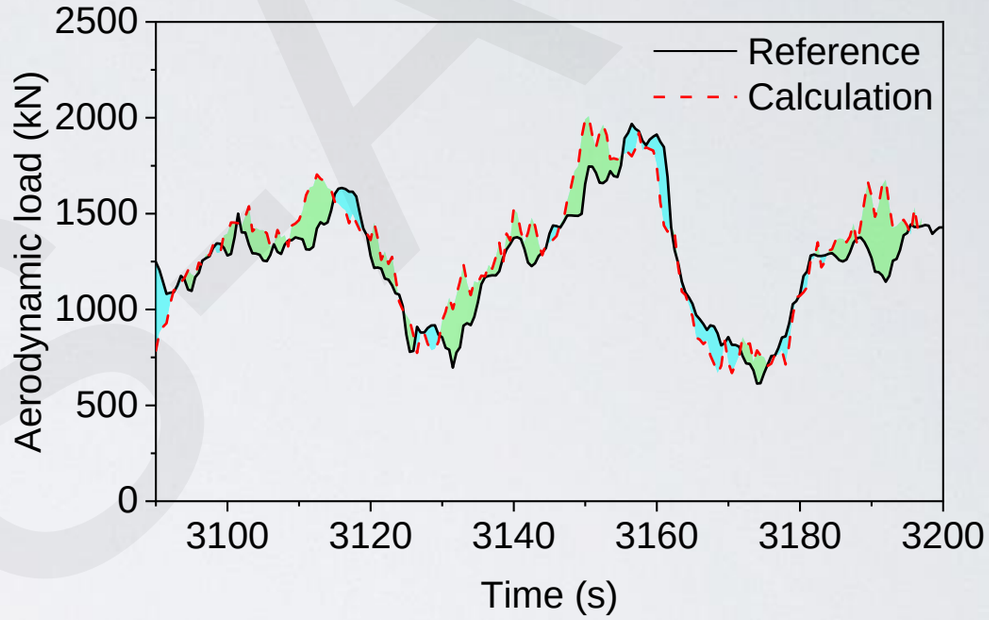


Platform motion

Scaled model tests were carried out to collect sample data

Results and Conclusions





For the hydrodynamic load measurement, the curve-fitting degree is 92.44% and the root mean square error is 4.20%.
For the aerodynamic load measurement, the curve-fitting degree is 79.83% and the root mean square error is 10.68%.
In the future, we envision this method being applied to actual full-scale FOWTs in real sea states. This would involve using more measurement equipment with high accuracy and high sampling frequency.