Title of Diploma Thesis

Prediction of Wave Breaking Loads on Offshore Wind Turbines' Monopile Foundations by Artificial Neural Networks

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Academic Year

2022-2023

ABSTRACT

This diploma thesis aims at developing an Artificial Neural Network (ANN) to predict the horizontal force due to breaking waves on the monopile of an offshore wind turbine. This is an alternative approach to the solution of a nonlinear problem, which, additionally to the adoption of multiple assumptions in case of analytical solutions, it requires either the implementation of laboratory experiments or the development of complex and computational expensive CFD numerical models.

The ANN is developed using MATLAB® and it corresponds to a multi-layered, feed forward and fully connected network. The input vector includes the diameter of the monopile, the breaking wave height, the peak wave period and the water depth at the installation location, while the ANN is trained using a variation of the standard back-propagation algorithm, based on the Levenberg-Marquardt optimization method for minimizing the errors. The data required for training, validating and testing the ANN are collected from laboratory experiments and they are appropriately pre-processed prior to their deployment as input to the network. Extensive tuning tests are carried out in order to determine the best network architecture. Specifically, networks with one and two hidden layers and various neuron arrangements are investigated and compared. For each network, 10 training tests are initially performed by selecting randomly the training, validation and test data sets, and the best one is selected for further comparison with the rest examined architectures. The performance of each network is evaluated through various criteria including the mean square error, the correlation coefficient and error distribution histograms. The results illustrate that for the data deployed in the present investigation the best architecture for predicting wave breaking loads on a monopile corresponds to a two-hidden-layer network.

Keywords: Artificial Neural Network, Prediction, Breaking Waves, Extreme Loads, Monopile, Offshore Wind Turbines.