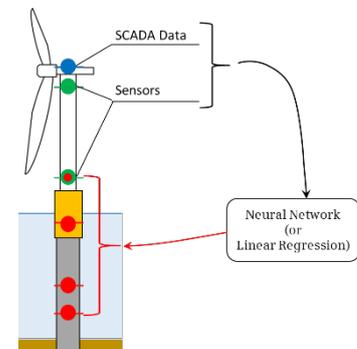


## Fatigue Assessment of Offshore Wind Turbines using Measurements of Individual Turbines and Machine Learning Techniques

Fatigue is often a governing design factor for offshore wind turbines. Since the design of offshore wind turbines includes conservatism, the actual accumulated fatigue damage can be lower than what the turbine is designed for. In this case, the operator can make a decision on life time extension of existing wind turbines. Therefore, it is important to estimate the actual accumulated fatigue damage to support decision making on life time extension, and for optimization of support structure design. However, fatigue critical locations are located near mudline where it is unfeasible to install strain gauges to measure the accumulated fatigue damage.

The first purpose of this thesis is to investigate if data-driven approaches (linear regression and feed forward neural network) can be applied to estimate the accumulated fatigue damage both in individual turbines and farm-wide. The second purpose is to determine the minimum number of sensors and quantity of data required for accurate estimation.

Towards this goal, real measurement data of two offshore turbines in the same wind farm have been used. Specifically, the data-driven approaches have been applied with real measurement data from the SCADA systems, measurements at the top and bottom of the tower, and data from a wave measurement system. This data was used to estimate the accumulated fatigue damage at multiple locations (tower bottom, transition piece and two levels on the monopile) in the form of damage equivalent loads. Throughout the study, 10 min statistical properties of the measurement data have been used as input to the learning algorithms. One remark is that the estimation has not been performed for the fatigue critical location near mudline itself, but it is expected that estimation with these approaches can be expanded to the fatigue critical location if accurate response estimation at multiple locations on the support structure is possible.



The results of this thesis show that the data-driven approaches can give accurate estimates damage equivalent loads on individual turbine level at multiple locations on the support structure when moment or inclination signals at tower bottom is used.

For farm-wide level estimation as well, it has been proven that the data-driven approaches can give quite accurate estimates the damage equivalent load. However, it should be noted that the turbines used in this study have similar dynamic properties. Therefore, the farm-wide level estimation with the data-driven approaches should be further investigated in the future.

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