MSc. Thesis: Application of neural networks to build reduced order models of wind turbines mechanical components

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Period: 6 months
Begin: flexible
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1. Background

Machine learning has been currently a trend in various engineering fields, not to mention its application to renewable energy resources specially wind energy. Its potential has been exploited in different applications related to enhancement of performance of wind turbines and wind farms such as using Big Data from measurements to improve the design and engineering process of wind turbines, improvement of operation of wind farms by using machine learning techniques with the aim of increasing lifetime of mechanical components, increasing annual energy production (AEP) using modern control techniques.

2. Objective

Digital twins are dynamic and virtual representation of the physical systems. They use live data coming from sensors during operation to help estimate the internal system states. The objective of this master thesis is to build reduced order models of mechanical components of wind turbines such as tower or blades. These reduced order models (ROM) are used as the core of a digital twin that can estimate these internal system states. In order to be able to build such ROMs, huge set of data should be used to train and validate the formulated data models. This data set is generated using either measurements from real wind turbines or high-fidelity simulation models (multibody system simulations, finite element simulations, etc.). Neural networks have great potential in formulating reduced order models of dynamical systems using time series prediction techniques such as autoencoders using recurrent neural networks (RNN).

3. Plan

a. Literature review of nonlinear system identification
b. Familiarization with the available physical simulation models of the wind turbine and its subsystems such as blades, tower, etc.
c. Construction of virtual test bench for generating required training data using MBS and FE simulations
d. Formulation of the reduced order models using e.g. neural networks
e. Validation and testing of ROMs

4. Requirements

a. Student of mechanical, aerospace, or energy engineering
b. Knowledge of wind energy and aeroservoelasticity,
c. Knowledge of multibody system simulations (preferably using Simpack) and finite element simulations (preferably using ANSYS)
d. Knowledge of scientific computing using Python and Matlab
e. Basic knowledge of data science and machine learning using Python world: Matplotlib, Numpy, Pandas, Scipy, scikit-learn, Tensorflow, Keras