

Final project topic proposal: Load forecasting using Lidars and Machine Learning

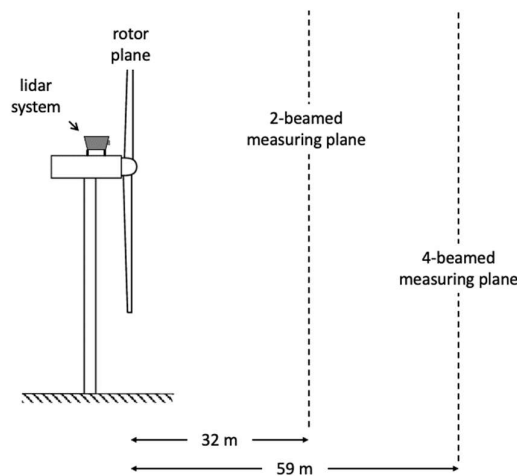
1. Introduction

Nacelle-mounted lidars have the ability to measure the wind ahead of the rotor thereby providing a preview of the upstream wind field. This preview could potentially be used for a feedforward control approach where the wind turbine would have time to mitigate extreme loads before the hit.

The main purpose of the project is to train a ML model to forecast structural loads at different forecast horizons using only lidar measurements as inputs. In addition, the newly developed model will be assessed in terms of uncertainty, as well as sensitivity to the choice of hyperparameters such as the forecast length and the amount of historic data used in the forecast.

2. Approach

The experimental setup is shown in the figure below. It consists of a Vestas-V52 wind turbine equipped with a strain gauge system for measuring structural loads and two lidar systems, namely a 2- and 4-beamed lidar system. The two lidar systems measure at different distances ahead of the rotor.



The dataset contains synchronized measurements from the systems. The objective will be to build a model that takes only lidar measurements as inputs and forecast structural loads at the relevant forecast horizons.

Several modelling approaches might provide useful results. Some of the potential approaches are:

- Multivariate sequence model (i.e., using several time series inputs like wind speed, wind direction, to predict future loads). Could be implemented with an LSTM model.
- Multi-lagged discrete model.

3. Implementation specifics

When running forecasts, we are dealing with time series and capturing/modelling the time dependence properly is of high importance. We need to make sure our time series are continuous - i.e., adjacent rows in the data are exactly one time step apart, otherwise we lose the autocorrelation and time dependence information. Keeping track of time dependence is facilitated by using the time stamp as an index of the data – e.g. by using data frames (the pandas library in Python). Then one can either fill missing data points or limit the analysis to periods where there's no gaps in the data.

4. Formal requirements

The final project gives the students the possibility for applying the knowledge gained on the course to a problem relevant to their own technical interests. The topic and goals of the project are agreed individually between the students and the teacher. The solution should involve methods within the scope of the course, and the results of the project should demonstrate that the student has to a significant degree achieved the learning objectives.

The report on the project should reflect this purpose, and should contain at least the following information:

- Description of the problem/topic of the study.
- A brief description of the methods used, including the most important equations and supported with references.
- A description of the solution procedure with examples and demonstration of results in a suitable form.

Jupyter notebooks are a useful tool for running Python code along with including description and documentation. However, it is not recommended to directly submit final reports in Jupyter format (or a pdf printout of the Jupyter notebook), due to the usually low quality of the formatting and sometimes a lot of unnecessary items. It is still allowed to submit a Jupyter notebook but only in case the formatting quality is comparable to that of a report written in e.g. Word.

When defining the project details, care should be taken so that the expected workload will correspond to what is expected of a student for achieving 5 ECTS points. It is allowed for students to work individually as well as in groups of two or three. A reasonable project ambition corresponds to individual efforts of each participant comparable to the efforts required for completing e.g. Assignment 2 and 3 in the course.

The students have to submit a report describing the final project and its outcomes. The report should be submitted as a single pdf file with the name of the student(s) indicated on the title page. In case more than one student has worked on the report, the specific contribution of each student has to be explicitly described in the report. Just stating that everyone has equal contribution is not desirable as it does not allow distinguishing the work of individual students. The total length of the project report should be less than 6000 words.