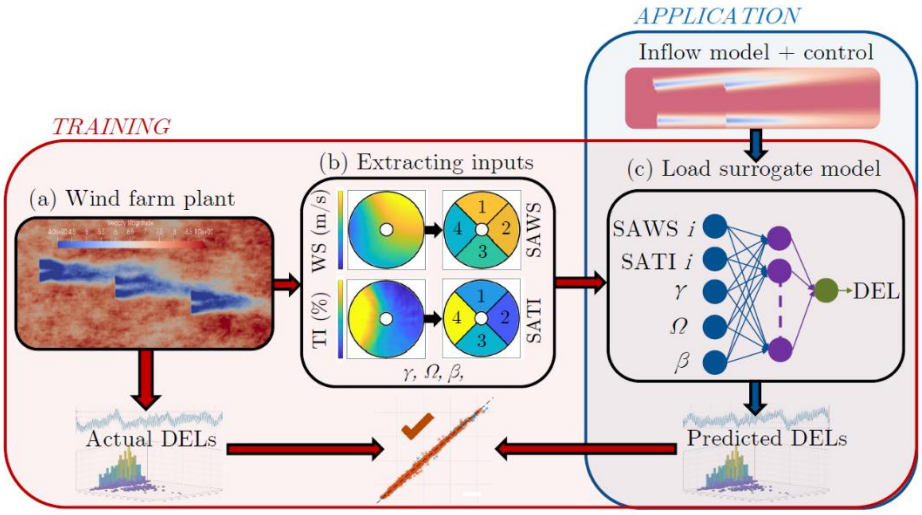
Development of a location-agnostic load surrogate model considering wind farm effects based on single turbine simulations.

One year student job position at ENERCON

First: research internship / Semester thesis proposal, then: Master's thesis

TUM Wind Energy Institute in collaboration with ENERCON

Logos of TUM's Wind Energy Institute (left) and ENERCON (right)



TUM's approach for location-agnostic and control-oriented load surrogate model, based on multi-turbines simulations (FAST.Farm) [1].

Background and motivations

Determining the structural fatigue loads of wind turbines require computationally expensive aero-servo-elastic simulations on the wind farm level. Although the most classical approach in the industry is based on Effective Turbulence model (i.e. considering homogeneous increased turbulence due to wake effects), it has been shown to be quite conservative in some cases [2-4]. More advanced simulations based on the Dynamic Wake Meandering (DWM) model have been developed and validated, as in [5-6]. However, these aero-servo-elastic simulations on the farm level are too computationally intensive to be directly integrated in optimizations for application in layout design or wind farm control actions considering load alleviation. For this reason, the development of computationally cheap but accurate load surrogate models has been of recent research interest, as in [7-9]. These approaches are however layout-dependent (requiring new training if the wind farm layout

is changed) or do not include the complex effect of control actions (yaw misalignment or curtailment) on the loads of the actuated as well as downstream turbines. At TUM, a novel generic approach of control-oriented and location-agnostic has been developed and validated, as illustrated on the figure above [1]. Although its large generality, this surrogate model (like all) is specific for a certain turbine type (in this case, the IEA 3.4MW turbine). Applying this method to a new turbine type requires to run a large number of new simulations on the wind farm level (FAST.Farm is used up to now). Alternatively, running simulations for single turbine would be much faster. A surrogate trained on a dataset based on single turbine simulations could still perform well, as long as all the relevant effects of local (waked) inflow on the loads can be incorporated.

A cooperation is being launched with the company ENERCON, as part of a research project. The long-term goals are to efficiently train and validate a new load surrogate for one of ENERCON's turbine model based on TUM's method [1]. The validation of the surrogate shall first be made in simulation environment, and later on using full-scale field measurements.

To start this activity, the first research question is: *"Is it possible to train a location-agnostic and control-oriented load surrogate model such as [1], based on single turbine simulations that incorporate wake effects?"*

The internship aims at answering this question, by running a set of single-turbine simulations and training a load surrogate. Validation against farm-level simulations should give quantitative results on the performance of such a surrogate that was efficiently trained.

Goals of the internship

- Literature research to get familiar with the described models and methods.
- Running a large set of single turbine aero-servo-elastic simulations using the DWM option in DNV's BLADED code [10]
- Training a load surrogate model from the newly built dataset, following [1]
- Assessing the performances of the surrogate in new conditions, if possible on the farm level

Requirements

- Availability for one year (planned time for the student job contract at ENERCON), which can be split into research internship and Master's thesis for the university side
- Excellent basis in mechanical engineering (aerodynamics and structures)
- Strong interest in the topic and work autonomy
- Advanced experience in at least one programming language (preferably Python), numerical methods (ideally machine learning techniques) and data handling.
- Fluent in written and spoken English.
- Passionate to work on the green energy transition within a motivated team of engineers.
- Experience in wind turbine simulations (OpenFAST, Bladed, HAWC2, etc.) is highly beneficial

Practical information

- Student job contract with ENERCON, with associated monthly remuneration, for one year
- NDA to be signed between the student, the TUM Chair & ENERCON
- Work location at Bremen (after some weeks of training at TUM) – transport and accommodation has to be setup independently. At least ~20% of the project time should be spent in the offices of ENERCON in Bremen
- Starting date to be determined together with the student and ENERCON

About ENERCON's team

Innovative ideas and excellence are at the core of our success at ENERCON. We are passionate about realizing wind energy projects worldwide and to master the technological challenges of tomorrow. You can join us and contribute with your commitment to shape the future of renewable energy!

We are a specialist team within the research and development part of ENERCON, responsible for developing tools and methods for site-specific mechanical load assessments of wind farm projects and ultimately the optimization with regards to turbine lifetime and yield.

If you enjoy working on the interface between physical modeling, numerical simulation and software development, if state-of-the-art technologies like machine learning is something that thrills you, and if wind energy and the behavior and interaction of wind turbines is exactly your area of interest, then join our motivated team of engineers!

Contact

If interested, please send your CV and course records to:

Jan Krause, jan.krause@tum.de

Adrien Guilloré, adrien.guillore@tum.de

References

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