State Estimation of a Wind Turbine Model using Physics Informed Neural Networks and Cascade Observers

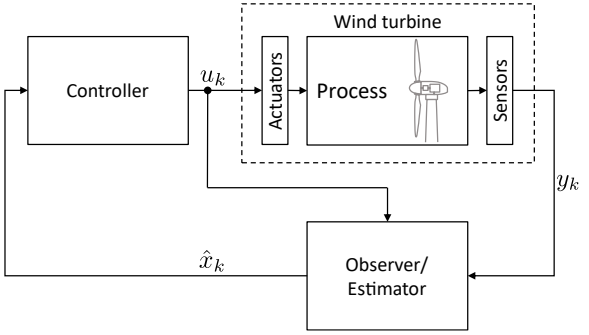
TECHNISCHE UNIVERSITÄT DARMSTADT

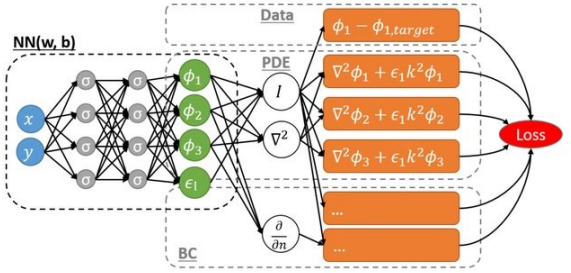
Master‘s Thesis

Wind turbines are highly nonlinear, dynamical systems with complex disturbances, such as varying wind speeds. In order to efficiently control such systems, modern wind turbine controllers (e.g. Model Predictive Controllers) need precise knowledge of the wind turbine system states. Since not all states can be measured directly, the use of state estimation techniques becomes necessary [1].

Within the scope of this master thesis, you will investigate Neural Network-based state estimation techniques for a wind turbine model [2]. As the system dynamics of wind turbines are of high order, it is necessary to estimate not only the positions of wind turbine components, but also their derivatives. Knowledge of this coupling between system states is not readily available for learning-based approximations, however, it is being investigated in recent years via the framework of Physics Informed Neural Networks (PINN). Your task would be to determine applicability and potential benefits of applying PINNs for reconstructing the wind turbine’s states from the available measurements.

Wind turbine models normally omit less pronounced effects, e.g., averaging the dynamics of the (three) blades of the wind turbine, discarding effects such as tower shadowing or wind sheers. As computational complexity is low for learning-based observers, they can potentially be used to determine more detailed state estimates. In this work you will consider NN-based estimation of separate blade states and a cascade observer design, where the individual blade states will be determined using the observer for the averaged states first. This could be achieved by either chaining two Neural Networks (essentially fixing the latent space), or by combining classical observers, such as Kalman filters, with a Neural Network component.





Zhang, Qi & Chen, Yilin & Yang, Ziyi. (2020). Data-Driven Solutions and Discoveries in Mechanics Using Physics Informed Neural Network

[1] F. Häusser. Real-time capable State Estimation for a Wind Turbine Model. Master thesis, Institute for Automation Engineering, University of Magdeburg. 2020.

[2] https://github.com/jgeisler0303/CADynTurb

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