The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Wind Turbine Control using Machine Learning techniques

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Keywords: *Wind Energy, Wind Control, Reinforcement Learning, Genetic Programming*

Wind energy is an environmentally friendly and cost-effective solution to the ever-increasing energy demand. As modern wind turbines continue to increase in size, operational and maintenance costs, the closed-loop control of their performances becomes crucial to their economic viability. Traditional control systems acting on blade pitch and yaw angles or on the generator torque are based on Proportional Integral Derivative (PID) controllers. These are calibrated around different design conditions using linearized models of the wind turbine dynamics [2]. The linear framework simplifies the control design and is robust close to design conditions. However, it provides sub-optimal performances in transient conditions and blade overloading when approaching the power-limited regime [1].

This work aims to design a wind turbine controller using state-of-the-art machine learning techniques such as Reinforcement Learning (RL) and Genetic Programming (GP). These approaches do not rely on a system model and learn by trial-and-error, potentially overcoming the short-coming of over-simplified models. Both RL and GP were implemented in a numerical environment combining a simple dynamical model for the turbine rotor dynamics, with a Blade Element Momentum (BEM) theory computation of the aerodynamic loads and an aero-elastic model for the structural loads of the blades. The wind turbine model was constructed using the open source code openFAST [3], which is a popular design tool in the wind-engineering community. The performances of the GP and RL controllers are tested and compared against the classic adaptive PID controllers for different operating conditions of the wind turbine and different wind transient scenarios. Emphasis is placed on the number of iterations needed to train the control algorithms and the balance between the complexity of the control parametrization versus actuation effectiveness [4].

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