Abstract No.

LIDAR Assisted Model Predictive Control of Wind Turbine

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Traditional turbine controller usually acts slowly because of a complex electromagnetic system and huge mechanical device. It is difficult for turbines to respond to the current wind situation in a short time. In contrast to the anemometer which measures wind speed and direction on the nacelle, the development of LIDAR technology provides an opportunity to obtain wind data in advance and remotely.

In this paper, a Doppler LIDAR is manipulated to detect the optimal measurement distance and average speed of preview inflow wind in front of the rotor plane. Based on doppler theory, a Gaussian distribution weight function is applied to focus one measurement point from a big volume of the laser. Doppler Beam Swinging technique helps to reconstruct the 3D wind map from the limited information, i.e. line of sight wind speed detection of LIDAR [1]. According to multi-points results, the average wind speed and direction are calculated.

Model Predictive Control (MPC) is proposed because of its strong capability of processing the predictive information from sensors. After defining the cost function which maximizes the energy harvesting, the optimal problem is described through mathematic functions [2]. Time horizon section and feedback loop of MPC keep updating at every time step to guarantee the optimal solution in real-time. This optimal problem is computed with a MATLAB toolbox and then coupled with the turbine simulation in a DLL format.

Based on variable speed generator torque and collective pitch control, it is possible to find the optimal pitch and torque for different inflow wind speeds. There are three zones divided by wind speed at cut-in, rated and cut-off, the torque runs in an optimal strategy around the rated speed. Based on blade characteristics, the pitch angle and generator torque follow optimal tip speed ratio and torque restrictions respectively [3]. Lastly, we need to identify the scheduled pitch angle and torque as reference for MPC.

For the numerical simulation of the turbine, the proposed MPC is designed in the OpenFAST platform, where a 1:75 scale model of the DTU 10MW wind turbine aeroelastic model is applied [4]. OpenFAST estimates the output of the turbine, such as power generation, rotor torque and blade loads. On the other hand, high fidelity CFD of the entire wind field is accomplished in the SOWFA platform [5]. To simulate the process of LIDAR measurements, four wind sampling points from the SOWFA are compared with the wind estimation using the Doppler Beam Swinging technique.

Comparing MPC with traditional wind turbine controllers, the simulation results show that LIDAR assisted MPC has great advantages showing a power generation increase. In future research, the wake and turbulence will be involved in the LIDAR measurement to reduce their effects on the downstream turbine and maximize the power of the wind farm.

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Images:
Link: https://s3-eu-west-1.amazonaws.com/static.vcongress.de/cms/forwind/paper/eb38cd46-f3dc-4cd0-b8fa-0da6e64a9ed5.png
Description: Figure 1. Structure of LIDAR Assisted MPC

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