Review - Adaptive robust observer-based control for structural load mitigation of wind turbines

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Summary

The objectives of this paper is to improve on mitigating structural loading in rotor blades and tower with a good rotor speed and power regulation performance in the presence of model uncertainties and changing operating conditions. The main problem with the paper is that the improvement is demonstrated by comparing one already developed controller with a extension where both are made by the authors. Preferable it should be compared to results by other and or controllers made by others. On top of this the assumed known inputs as the (precise) hub wind speed and the tower based bending moment is not realistic. Also the assessment does not include the standard performance measures. The methods used in the paper are well know. Based on this and my comments below I at least suggest a major revision.

Specific comments

1. Abstract: "With growth in the physical size of wind turbines, an increased structural loading of wind turbine components affecting operational reliability is expected" Why is a small 1.5MW turbine used for testing instead of a more modern one e.g. the 10MW or 15MW IEA(DTU) RWT?
2. 3 Robust observer-based control:
   (a) The linearization is performed numerically by FAST. The FAST model has 16 DOF's. Only a subset is chosen for the control design model. Please motivate the choice of DOF's an corresponding states in (2).
   (b) When only the flap wise blade movement is included how is the IPC effect on the drive train modeled?

(c) There seems to be only one input namely collective pitch. However, besides blade pitch angles generator torque is also a control handle. This is often used to control drive train oscillations. Why is this not included?

(d) "The measurements y include rotor speed w and tower-base fore-aft bending moment." The tower bending moment is not a available measurement on commercial turbines but normally nacelle acceleration is. This means the setup is unrealistic?

(e) "Because pitch actuator dynamics are faster than other wind turbine dynamics, it is modeled as a first-order lag (PT1)" The pitch actuator is modeled as a first order low pas (LP) filter. That's fine but the most important part of the pitch actuator is normally not the time constant but the limited pitch rate of 5-15 deg/s?

3. 3.1 Disturbance accommodating control for wind turbines:

   (a) F= 0 in (7) means the disturbance is constant!

      i. How does this fit with the mentioned step?

      ii. What is the interpretation related to the real turbine physics?

4. 3.2 Robust disturbance accommodating control:

   (a) In figure 1 there is a known disturbance "Hub-height wind disturbance d". On commercial turbines the wind speed is only measured by the nacelle anemometer which are very uncertain mainly do to being just behind the rotor. Please explain how this is accounted fore?

5. 4.1 Adaptive independent pitch control:

   (a) "As wind turbine rotor blades rotate, they experience varying aerodynamic loads at different azimuth positions due to vertical wind shear" The spatial variations will be slowly time varying. Maybe the vertical wind shear is the main effect depending on the site. In a wind farm, where most turbines are located, horizontal shear do to partial wakes might be as important as vertical shear. Please motivate the focus here?

6. 5.1 Performance measures for analyzing results:

   (a) The standard measure for fatigue loading is damage equivalent load (DEL) calculated using rain flow counting (RFC). Please explain why this measure is not even mentioned?

   (b) Please also include the actuator activity e.g. measured with total traveled pitch angles.

   (c) Drive train loads should also be evaluated?

7. 5.1.2 Frequency domain:

(a) This section seems to explain the Welch method even though there is a reference. Is this necessary?

8. 5.2 Step wind profile results:

   (a) Wind speed steps are not realistic! Please explain the value of this?