Review - Iterative feedback tuning of wind turbine controllers

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Summary

This paper gives a good presentation of an interesting alternative way of tuning wind turbine controllers.

- The contributions are not stated perfectly clearly. "The main contribution is therefore to show the (practical) application of IFT.." is clear but regarding the vaguely formulated contributions to IFT it is hard to understand if these are new results or already is in existing literature.
- More precise statements on the practical usefulness of the methods and cases demonstrated would be nice.
- There are also a number of minor issues that needs clarification.

Consequently a revision is recommended before publication.

Specific comments

- Abstract and Introduction section are good.
- P2 "The main contribution is therefore to show the (practical) application of IFT to existing wind turbines." Is this not a contribution of Navalkar and van Wingerden, 2015? Moreover, are the contributions in this paper non overlapping with the ones in Navalkar and van Wingerden, 2015?
- Eq (1) If r is constant the system is stationary so the expectation in (1) would be time independent. Why is the time averaging sum included? Is possible r time dependence assumed known? What would be the case for this application?

- P3 "It is clear that minimizing (1) boils down to computing the gradient $\partial J(\rho_i)/\partial\rho$ and Hessian R_i at every iteration." This assumes a convex problem? How do you know assures this?
- Eq (3)
  - Why doesn't $\partial J(\rho)/\partial\rho$ depend on r ?
  - The expectation operator E is not well defined as long as the stochastic part v of the model is not well defined.
- Eq (3)-(10) Explain how you handle the noise and expectation? Maybe you derive the gradients assuming no noise i.e. a deterministic system and then uses them even though there are noise. If so, is this correct?
- P6 2.4 IFT for systems with multiple controllers. You are referring to the drive train damping controller (DTDC) being active below rated where the generator torque is controlling the speed. Below rated the DTDC is normally not really needed because the speed controller ads damping in contrast to above rated where the generator torque/power is constant which gives no/negative damping.
- P10 "The natural frequency of the drive train dynamics... is at $\omega_r = 10.49 rads^{-1}$" What is the corresponding damping which is equally important?
- P10 Why are you using two inputs θ_1, θ_2 for collective pitch control?
- P10 Why do you choose Bladed over FAST?
- P11 "The controllers are discretized using the Tustin approximation and run at a sampling time of 0.01 s." Why using 100Hz sampling frequency when the DTD dynamics is having a frequency around 1.67Hz?
- P12 "in Bode diagram, it is recognized that the band pass gain K can be increased infinitely" In practice the torque "actuator" will have a high bandwidth and a (communication delay) in the order of milliseconds seconds so there will be a limit to the gain.
- P15 4.4.1 General analysis of results. "The wind field considered here has a mean wind speed of 14 m/s" Then this is mostly above rated (11.3 m/s) where the pitch controller is active and generator power is at rated. Is this the intention?
- P16 "4.4.3 Varying experiment length N" I am still confused about N. You can not really calculate the expectation in (1). Does the N amount to time averaging instead of ensemble averaging i.e. assuming ergodicity which might be OK?
- P22 "outputs a demanded collective pitch signal $\theta = \theta_1 = \theta_2$" Now suddenly I guess you assume a two bladed turbine? I assume the FAST 5MW turbine is three bladed as you also state in table 1?

- P22 “The IFT algorithm is applied so as to optimize the step response tracking of the controller in (35).” What is the relevance of a step change in speed in practice? I would think a step in power reference is more useful for derating wind farms or for primary frequency control.

- P23 5.2 Results of IFT for CPC. It is clear that the IFT method works as expected. However, the improvement over more traditional and simple tuning is not so clear as it is not easy to see what is done to do a fair simple tuning of the controller. For example regarding changing average wind speed a traditional CPC controller would also include some gain scheduling to change decrease the gain with increasing wind speed.

- P23 5.2 Results of IFT for CPC. In general it is problematic to compared two control design methods which can be tuned for different purposes/objectives and claim that one is superior. One way to do a more fair comparison is to use Pareto curves see e.g. Odgaard et al. [2015b,a].

References

P. F. Odgaard, T. Knudsen, and R. W. T. Bak. Optimized control strategy for over loaded offshore wind turbines. In *Proceedings of EWEA Offshore 2015*. EWEA, EWEA?, 2015a.

P. F. Odgaard, T. Knudsen, A. Overgaard, H. Steffensen, and H. Jørgensen. Importance of dynamic inflow model predictive control of wind turbines. In *9th IFAC Symposium on Control of Power and Energy Systems CPES 2015, New Delhi, India, December 9-11 2015*, volume 48 of *IFAC Workshop Series*, pages 90–95. IFAC, IFAC, 2015b. doi: 10.1016/j.ifacol.2015.12.359.