Review of the publication *Field comparison of load-based wind turbine wake tracking with a scanning lidar reference*

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Dear authors,

I enjoyed reviewing your well-written and relevant publication on the wake location estimator. One aspect I really value is the consideration of uncertainty and the resulting bounds. My criticism is mainly related to the methodology presentation. Some sections would benefit from some clarification and additional information.

With kind regards

Comments

Introduction

The introduction is, in my opinion, a bit too brief on related work and not formulated consistently. Please review the phrasing and connection of the different sentences to generate a better reading flow. In contrast, I think the discussion (section 4) is well written, especially the paragraph starting at Line 438, which connects this work well with similar ones.

I am missing the motivation to use an extended Kalman Filter. Why not apply an Ensemble Kalman Filter or an Unscented Kalman Filter? The paragraph starting with line 36 lists several works that have done some sort of tracking, but I am missing a phrase more insight into how these publications have solved the issue, how the publications are connected, and what their successes and shortcomings are. I am also missing the link to the, in my opinion, relevant publications
Towards the multi-scale Kalman filtering of dynamic wake models: observing turbulent fluctuations and wake meandering, R. Braunbehrens et al 2023
and
Closed-loop coupling of a dynamic wake model with a wind inflow estimator, J. Di Cave et al 2024

Line 24 - „encountered“ seems an odd choice. Do you mean „accounted for“?
Line 30 - Missing citation

Methodology

Line 64 - Missing citation

Line 78 - Wind shear exponent at 50Hz is used for what?

Line 98 - How does the height difference between the turbines affect this setup?

Line 109 - Is the assumption of zero mean justified? How are the matrices Q and R populated? Was some sort of normalization necessary?

Line 141-143 Please add a source or rephrase to make clear where this statement comes from.

Line 150 - The dynamic system for the wake center is, in principle, a random walk model. And, while a random walk's value is zero, an individual random walk is also expected to travel further away from the origin. Translated to the wake center, I would expect the model to be somewhat stable within a given region - if the wind direction does not change, we would expect the wake to meander within given bounds, e.g., +- 2D. This is even more the case for the z component, where we expect the wake to be within a narrower corridor.
Can the equations easily be adapted to incorporate this behavior? One approach could be to adapt Eq. 8a) (and 8b), respectively) to
`\dot{y}_w(t) = v_c(t) - k y_w(t) + n_{x,1}(t),`
where k is a feedback constant. However, the change would cause the meandering around the origin, which can then be offset with a changing reference.
To be clear, I think the chosen approach is valid if the system is continuously corrected. I just wonder if you do see the same limitations of the model, or if I am missing something?

Line 179 - What are typical values for „b,c,d“? Do they have a major contribution or are they minor compared to the rest?

Line 181 - Can you elaborate on M_max and R_mix? What do they represent, and how do you determine them?

Section 2.2.3 would strongly benefit from a figure to illustrate the different moments and angles, possibly also in connection with the incoming wake and the thereby resulting moments. The text is a bit tricky to follow the way it is written right now.

Section 2.2.3 should further emphasize the link between the states introduced in Section 2.2.2 and the output. Line 161 briefly mentions equation h(x,n) but then doesn't mention it again.

Equation 9-12 are a bit confusing to me: (9) introduces a method to calculate M_yaw, M_tilt and M_col based on sensor data, (10) then discusses how to get M^~(r_w), just to invert it to return a different way of also calculating M_yaw and M_tilt, followed by (12) which then tells the reader how to calculate M^~(r_w).
I think what you are missing is that the M_yaw and M_tilt from Eq(10) and (11) are estimates based on the estimate of M^~(r_w), which is based on the estimated states. If this is the case, please adapt the notation with the (^) symbol and think about reversing the derivation:
States -> r_w and \theta -> M^~(r_w) -> M_yaw and M_tilt
Maybe also add a similar block diagram to Fig. 2 with a more detailed flow of the signals.

Line 214 - Review the grammar of the sentence

Line 220 - I'd expect a list of the fitted parameters here / insight into the derived LuT.

Line 229 - I assume this is the azimuth of the lidar? Since the rotor azimuth was already defined with a variable in the previous sections. Maybe add a word to clarify that. Addition: Table 2 confirms that it's the Lidar azimuth; just change it here.

Equation 15 / 16 - Are \gamma_1 and \gamma_2 already defined?

Section 2.3.1 would profit from a sketch showing the different coordinate systems in relation to each other. This also makes it easier to interpret the results later on.

Line 243 - Is this an issue in the comparison to the load-based approach? Both aim to determine the wake center but at different positions. This question is also related to the fact that the turbines seem to have different heights (as indicated in Section 2.1).

Line 244 - Missing citation

Figure 5 has a very brief caption; I'd add where the data is coming from (lidar, I assume). Also, indicate the wind direction.

Section 2.3.3 / Table 2 How are the uncertainties defined? Are the \pm values upper and lower bounds or standard deviations?

Results

Figure 9 - Based on the explanation of „Geometry“ I would expect it to be a line / some sin or cos. However, around (205 deg, 150 m), the scattering shows a spread, the same for the other end of the data. How come?

Line 311 - There is no figure supporting the claim of the asymmetry during yawed conditions. Consider adding a second figure to Figure 11 with the data.

Line 313 - I suggest to remove the „However“.

Figure 12 - The jet/rainbow colormap leads to severe misrepresentation of data and should not be used. For more information, see Figure 3 h) in *The misuse of colour in science communication*, Crameri et al. 2020, https://www.nature.com/articles/s41467-020-19160-7
Note that WES also cites this publication in their submission information https://www.wind-energy-science.net/submission.html#figurestables

Figure 12 - a)-e) These are some of the main results of your paper, I'd increase the size of the figures significantly and add the then current wake location estimate. Consider removing double y-Axis for instance to get more space

Line 335 - Is it worth to add a subplot to Figure 12 with the yaw angle of WT1, and the wind direction? Additionally, Figure 12 does not indicate where the wake would be if it wasn't deflected due to the wake steering. If you add the geometric reference, this will become more visible.

Discussion

Section 4.2 contains a lot of comparisons. Is it possible to visually put them next to each other? It might make it easier to see if there is a common trend or significant differences.

I am missing a Data & Code availability statement.