Lidar-based wake tracking for wind farm control at alpha ventus

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Motivation:
Wake redirecting is a promising approach to
- increase the power output of the wind farm
- decreased the structural loads induced by the wake interactions.

Why using a lidar:
- Using optimized yaw angle is open loop (sufficient in defined simulation conditions).
- A nacelle-based lidar system could close the loop by tracking the wake.

Approach:
full mathematical description of:
- a lidar measurement
- a wind turbine wake
- a reduced wind field
⇒ nonlinear model fit for each lidar measurement sequence to obtain the parameters of the models:
- wind speed, shear, misalignment
- wake characteristics displacement, dissipation rate, extracted power

Wind Field Model
- effective wind speed
- vertical shear
- horizontal misalignment
- Taylor’s frozen turbulence hypothesis
- superposition of the wake deficit

Wake Model
- initial wake deficit based on the power coefficient of the turbine
- energy dissipation modeled by a 2D filter with dissipation rate

Lidar Model
- assuming point measurements
- line-of-sight wind speed extracted from wind field

Experimental Setup
- SWE Lidar scanner nacelle-mounted on AV 7 facing downwind
- 7x7 measurement grid in 5 distances
- from March 11 to July 11

Wake Tracking Algorithm
\[ \min_x \sum_{i=1}^{n} \left( \bar{v}_{\text{los},i} - v_{\text{los},i} \right)^2 \]

Conclusion:
- The approach enables the tracking of the wake center.
- This can be a necessary step towards a field testing of wake redirecting.

Outlook:
- Currently implementing wake tracking algorithm in SOWFA.
- Feedback controller design to redirect the wake based on lidar measurements.