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Bayesian updating of uncertainties in an experimental downwind turbine

Rakesh Sarma[1], Richard P. Dwight[2] and Axelle Viré[3]

[1] Aerodynamics Group, Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, The Netherlands, R.Sarma@tudelft.nl
[2] Aerodynamics Group, Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, The Netherlands, R.P.Dwight@tudelft.nl
[3] Wind Energy Group, Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, The Netherlands, A.C.Vire@tudelft.nl

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Wind turbines operate under uncertain loading conditions, such as uncertain wind velocity or material properties of the blade. The varying load on the turbine blade can not only result in variable power production, but also negatively impact the life cycle of the blades. In particular, in wind turbines of downwind orientation, due to the blades being subjected to the tower wake at every rotation, uncertainties in the rotational speed of the turbine can lead to large fluctuations in blade loading. These fluctuations can lead to structural failure, for example due to fatigue [1]. In this paper, we explore the effect of these uncertainties on the blade loading in an experimental wind turbine [2].

Initially, in order to reduce the computational costs, a reduced order model based on a data-driven framework is developed to predict unsteady aeroelastic blade loads. This model provide an accurate representation of the load fluctuations due to the tower wake forcing. Thereafter, uncertainties are introduced in the structural and rotational parameters of the wind turbine, which are motivated by the experimentally observed variations. These uncertainties change the blade moment significantly, even for moderate uncertainties. Further, experimental measurement data on the blade moment is introduced in a Bayesian framework in order to perform structural and rotational parameter estimation. Finally, the identified parameters are propagated to reduce the uncertainties in the blade forcing on the blades. This methodology can be used for probabilistic estimation of fatigue during blade design.

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