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Opinion Article

Mechanism Involved in Wind Turbines

Paolo Stefen*

Department of Environmental and Mechanical Engineering, Massachusetts Institute of Technology, California, United States

DESCRIPTION

As wind turbines are designed with longer blades and towers, it becomes increasingly important to factor structural modes into the design of the controller. In classical turbine controllers, where pitch- speed, torque- speed, drivetrain and tower dampers are designed separately, it has for times been commonplace to base that design on a linearization of the being high- dedication aero elastic model. Furthermore, any measurement filters that are required at run- time are included in the control loop shaping process. In contrast, most previous work on Model Predictive Control (MPC) for wind turbines uses simplified models and ignores the need or effect of measurement filters. In this work, we demonstrate a mostly automatic design process that takes a detailed linearized model from an aero elastic simulation package and adds direct filters and feedback, to produce a model predictive controller with low run- time computational complexity. The tuning process is mainly simpler than classical control, making it an attractive tool in industrial applications.

Due to the increasing size and flexibility of ultramodern wind turbine designs, more blade and tower vibrational modes lie within the controller bandwidth, meaning those modes must be included in the model on which the controller is designed. Input constraints are accommodated through anti-windup strategies, but no constraints on the system outputs are guaranteed.

Model Prophetic Control (MPC), in discrepancy, is an optimisation subject to constraints on inputs and outputs. It has an intuitive tuning process where the trade-off between control activity and output deviations is defined as a quadratic cost function.

Minimisation of that quadratic cost subject to linear constraints is known as a Quadratic Programme (QP), which can be rapidly solved online on even a modest computer, provided the number of degrees of freedom is kept low. MPC makes predictions of the future countries of the plant in terms of those degrees of freedom and the current estimated state. With a linear prediction model and linear constraints, the optimal control action to apply to the plant at each time step can be found by solving a single QP.

Rather than erecting the QP online, starting from the estimated state and multiplying by the dynamical system matrices for each vaticinator step in the horizon, the QP is formed offline with the estimated state as a variable. It isn't an optimisation variable — its value is known at run- time and is applied to the QP as an equivalency constraint. This allows vaticination models with a large state space (around 100 countries) to be used in MPC without significantly impacting the run- time computational demand. What dominates the complexity of working the QP is the number of optimisation degrees of freedom, which in the present work we keep low by using base functions to collude optimisation variables over the vaticination horizon.

While the size of the state isn't a computational concern, estimating the state directly is a challenge, especially when there are numerous further countries than measures. The present work shows how direct feedback, in addition to the MPC optimal control action, can prop state estimation.

The capability to efficiently break the QP despite a large state space allows us to use direct models directly from an aero elastic design and simulation software similar as Bladed. This brings benefits in artificial operations, since changes to the wind turbine model can be propagated into the direct model with minimum trouble. Also, compared to first-principles modelling, aero elastic linearization captures further coupling between aerodynamics and the structure and requires lower moxie to perform. Indeed, the crucial donation of this paper is an MPC design process that accepts direct models with a large state space can be fluently configured and tuned and can be solved rapidly online.

While the modelling methods, application of MPC theory and validation in that work were thorough, switching between regions isn't optimal, performing in transients (albeit filtered) during region transitions.

Employing multiple linearization improves optimality for a plant where the poles and bottoms change in different operating regions, as they do in a wind turbine. Still, they aren't rigorously needed, if a decrease in performance is acceptable when operating away from a single linearization point. The basic purpose of the controller is to maximise power capture subject to constraints on generator speed and torque and pitch actuator angle and haste. Since constraints are handled naturally by MPC, the simplest approach with a single model is to define the cost function with a variable reference, which tracks the operating mode at run- time based on an estimate of the wind speed.

Correspondence to: Paolo Stefen, Department of Environmental and Mechanical Engineering, Massachusetts Institute of Technology, California, United States, E-mail: stefenaolop@ford.edu

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