COMPUTATIONAL RESEARCH in BOSTON and BEYOND SEMINAR

Hybrid Modeling for Energy System Simulation and Control

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ABSTRACT:

Simulating and controlling energy systems, such as buildings and wind farms, often requires a tradeoff between accuracy and computational speed. I explore how hybrid methods can combine the best attributes of each constituent method and thereby achieve both accuracy and speed. First, I consider high-fidelity simulation of a wind farm. Typically, simulations accurately represent only a subset of the following: blade boundary layer dynamics, wake-atmospheric boundary layer (ABL) interactions, and turbine-turbine interactions. I develop a hybrid between two fluid models, one Reynolds-Averaged Navier Stokes (RANS) and one large eddy simulation (LES), to simultaneously capture all three effects. I implement this work in a massively parallel flow solver, Nalu-Wind, and run simulations on a supercomputer, Eagle. Second, I compare a range of model-based, learning-based, and hybrid methods for real-time control of a grid-interactive building. The model-based approaches are accurate but require slow online optimization. In contrast, the learning-based approaches are rapid online but require lengthy offline training. I show that hybrid methods can achieve high accuracy while running quickly online and offline. Finally, I apply the most promising method from building control, differentiable predictive control (DPC), to wind farm control, specifically wake steering for power maximization. Typically wake steering methods develop a lookup table that maps wind farm conditions, such as incoming wind speed and direction, to the yaw angle for each turbine in the farm which maximizes the total wind farm power. If any turbines in the farm shutdown, the lookup table leads to sub-optimal control; extending the table to account for shutdown would be computationally prohibitive. I show that DPC can accomplish wake steering under turbine shutdown while maintaining low online and offline computational cost.

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