Coordinated Learning for Wind Farm Optimization*

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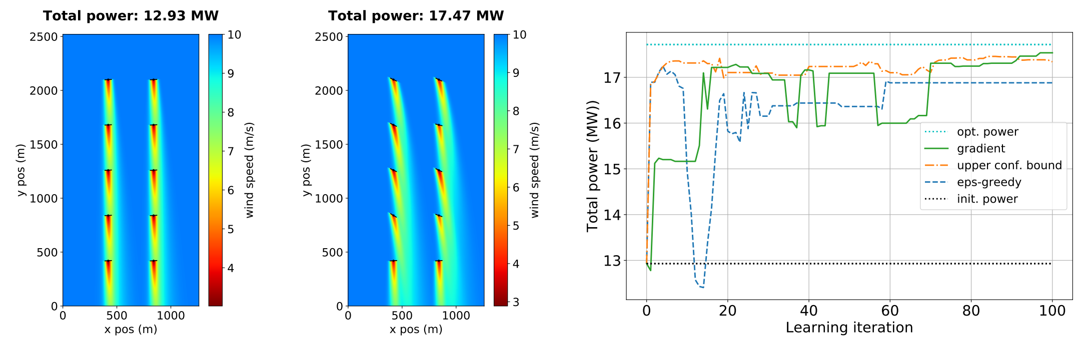
Optimal efficiency and loads alleviation in a dynamic environment necessitates a wind farm controller that can anticipate and quickly adapt to changing wind and wake conditions. In this work, we explore several strategies for collective learning and optimization, first using a high-level parametric wake model[1], and then a more complex approach, i.e. Large Eddy Simulation (LES) coupled to a wind turbine model.

We first used a parametric wind farm model with simplified wake dynamics to develop and test a set of optimization and learning algorithms in a variety of layouts and wind conditions. The initial objective was to maximize the power output by controlling turbine rotation angles and power induction factors, while minimizing the required number of iterations. The learning algorithms achieve close to the maximum power resulting from a centralized optimization in a constant free-stream wind environment.



(a) Initial (b) Learned (100 iter.) (c) Algorithm comparison

Figure 1: Turbines learn to increase total wind farm power output by defecting their wakes away from downstream turbines.

We plan to couple the initial learning methods with a more realistic wind farm model in order to refine and improve the learning algorithms. Specifically, we will use LES coupled to an advanced Actuator Disk (AD) method[2]. This approach has the advantage to accurately capture the unsteady wake behavior and the rotor dynamics, while keeping acceptable computational costs.

In the context of global control, the initial controllers of the wind turbine are modified in order to respond to the learning algorithm. The AD model is then equipped with down regulation procedures, which make it possible for the wind turbine to generate a desired percentage of the available power at every wind speed, and the yaw controller is adapted to follow a yaw angle command. These changes allow the use of a combination of induction control and wake steering in the learning process.

The first objective of this wind farm controller will consist in maximizing the power production. On a longer term, we will aim to extend the learning algorithm to account for fatigue loads.

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[1]Gebraad et al. Wind Energy **19.1** (2016)

[2]Moens et al. Wind Energy (2018)