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A Visually-Informed Decision-Making Platform for Wind Farm Layout Optimization

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Abstract

Wind Farm Layout Optimization (WFLO) is a typical model-based complex system design process, where the popular use of low-medium fidelity models is one of the primary sources of uncertainties propagating into the estimated optimum cost of energy (COE). Therefore, the (currently lacking) understanding of the degree of uncertainty inherited and introduced by different models is absolutely critical (i) for making informed modeling decisions, and (ii) for being cognizant of the reliability of the obtained results. A framework called the Visually-Informed Decision-Making Platform (VIDMAP) was recently introduced to quantify and visualize the inter-model sensitivities and the model inherited/induced uncertainties in WFLO. Originally, VIDMAP quantified the uncertainties and sensitivities upstream of the energy production model. This paper advances VIDMAP to provide quantification/ visualization of the uncertainties propagating through the entire optimization process, where optimization is performed to determine the micro-siting of 100 turbines with a minimum COE objective. Specifically, we determine (i) the sensitivity of the minimum COE to the top-level system model (energy production model), (ii) the uncertainty introduced by the heuristic optimization algorithm (PSO), and (iii) the net uncertainty in the minimum COE estimate. In VIDMAP, the eFAST method is used for sensitivity analysis, and the model uncertainties are quantified through a combination of Monte Carlo simulation and probabilistic modeling. Based on the estimated sensitivity and uncertainty measures, a color-coded model-block flowchart is then created using theMATLAB GUI.

Keywords: model-based systems design; particle swarm optimization; sensitivity analysis; uncertainty quantification; wind farm layout optimization.