Computational and Data-Enabled Science Seminar

Hyper-Differential Sensitivity Analysis with Respect to Model Discrepancy

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Abstract: Mathematical models are a building block for computational science and are a foundational tool to support decision-making. Outer loop analysis such as optimization is crucial to support decisions related to system design/control or estimation of unobservable processes. However, models are imperfect representations of complex physical processes and often require simplifications to achieve computational efficiency. The discrepancy between models and the physical system is frequently amplified by outer loop analysis such as optimization. As a result, the optimal solution determined from simplified or reduced models is insufficient to support critical decisions. We present a novel approach to compute the sensitivity of optimization problems with respect to model discrepancy and use this information to improve the optimal solution. By posing a Bayesian inverse problem to calibrate the discrepancy, we compute a posterior discrepancy distribution and then propagate it through post-optimality sensitivities to compute a posterior distribution on the optimal solution. In this presentation, we will introduce the mathematical foundations of hyper-differential sensitivity analysis with respect to model discrepancy, discuss its computational benefits, present results showing how limited high-fidelity data can significantly improve the optimal solution, and as time permits, discuss ongoing work exploring optimal data collection strategies to maximize improvements in the optimal solution.

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