Numerical Analysis and Scientific Computing Seminar

Sensitivity analysis in forward and inverse problems

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Abstract: Global sensitivity analysis (GSA) offers a flexible framework for understanding the structural importance of uncertain parameters in mathematical models. We focus on forward and inverse problems arising in uncertainty quantification and the computation of measures of variance-based sensitivity. The models involved in these problems are often computationally expensive to evaluate. Traditional methods for sensitivity analysis then come at an unreasonable cost. A preferred workaround is to create a surrogate model that is less cumbersome to evaluate. Surrogate methods that accelerate GSA are proposed and studied. A new class of surrogate models is introduced, using random weight neural networks for surrogate-assisted GSA, presenting analytical formulas for Sobol' indices. The proposed algorithm enhances accuracy through weight sparsity selection, as shown by its application to forward problems derived from ordinary differential equation systems. We also tackle sensitivity analysis in Bayesian inverse problems. A framework for variance-based sensitivity analysis of Bayesian inverse problems with respect to prior hyperparameters is introduced, along with an efficient algorithm combining importance sampling and surrogate modeling. The approach is demonstrated on a nonlinear Bayesian inverse problem from epidemiology, showcasing its effectiveness in quantifying uncertainty in posterior statistics.

Tuesday, April 9, 2024, 10:00 am
Mathematics and Science Center: MSC W201

Mathematics
Emory University