SCALABLE APPROACHES FOR DATA-DRIVEN PDE-CONSTRAINED BAYESIAN INVERSE PROBLEMS

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Inverse problems are pervasive in cyberinfrastructure research, especially in scientific discovery and decision-making for complex, natural, engineered, and societal systems. They are perhaps the most popular mathematical approaches for enabling predictive scientific simulations that integrate observational/experimental data, simulations and/or models. For inverse problems that serve as a basis for design, control, discovery, and decision-making, their solutions must be equipped with the degree of confidence. In other words, we have to quantify the uncertainty in the solution due to observational noise, discretization errors, model inadequacy, etc.

We choose to quantify the uncertainty in the inverse solution using the Bayesian framework. This approach is appealing since it can incorporate most, if not all, uncertainties in a systematic manner. Unfortunately, inverse/UQ problems for practical complex systems possess three challenges simultaneously, namely, the large-scale forward problem challenge, the high dimensional parameter space challenge, and the big data challenge. This talk presents multi-facet computationally-efficient methods to tackle these challenges simultaneously. Rigorous theoretical results and extensive numerical results for various applications including geophysical inversion and inverse electromagnetic wave scattering will be presented.