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Optimization Program Inverse Problems Workshop
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Lecture: *Optimal Experimental Design for Constrained Inverse Problems*

Speaker: Lars Ruthotto

Abstract:

This talk presents recent progress towards efficient numerical methods for Optimal Experimental Design (OED) for inverse problems in the presence of constraints. We consider ill-posed linear inverse problems where the measurement matrix depends on design parameters. In addition to Tikhonov regularization we assume that additional linear equality and/or bound constraints are present. A common goal in these OED problems is to enforce sparse sampling in the design parameters. We will discuss two OED formulations to achieve sparse designs. First, we use a fine discretization of the parameter space and develop a subsampling strategy in the design problem with a sparsity enforcing term. Second, we fix the number of non-zero design parameters and identify them by solving the corresponding nonlinear and non-convex optimization problem.

We present both a Bayes and an empirical Bayes framework for solving the OED problems. In the Bayes framework, we consider the unconstrained inverse state problem and exploit a closed form solution for the inner problem to efficiently compute derivatives for the outer OED problem. For the empirical Bayes formulation, we derive a bilevel optimization problem in which the objective function is the sum of the reconstruction errors for the given training data and the costs of the design. The constraints are given by the inverse problems which need to be solved for all training models. Derivative-based methods are a key to efficiently optimize the typically high-dimensional design parameters. We discuss challenges associated with inequality constraints and how to overcome them using relaxed formulations of the problem.

The talk is joint work with Julianne and Matthias Chung, Virginia Tech.