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Optimization Program Inverse Problems Workshop
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Lecture: ***Markov Chain Monte Carlo Algorithms for Linear Inverse Problems***

Speaker: John Bardsley

Abstract:

In this talk, I will begin with a review of the basic characteristics of inverse problems before moving into Bayesian methods for inverse problems. The connection between the choice of the regularization function in classical inverse problems and the choice of the prior probability density function (or simply the prior) in Bayesian inverse problems is well-known. Less well-known is that in imaging, Gaussian priors (quadratic regularization functions) can be derived from pixel-level statistical assumptions about the unknown image using Gaussian Markov random fields (GMRFs). GMRFs and their use in modeling the prior will be a focus of the first half of the talk. With the prior in hand, in order to perform uncertainty quantification, one often must sample from the posterior density function (or simply the posterior). In cases where both the measurement error and prior variances are unknown, which is typical, a so-called hierarchical model assumes hyper-prior probabilities on these scalar parameters, resulting in a non-Gaussian posterior. The problem of sampling from this posterior is the focus of the second half of the talk. We will begin by presenting a basic Gibbs sampler, discuss its drawbacks in terms of algorithmic performance, and then present alternative MCMC methods that have better performance characteristics, and that make use of a technique known as marginalization. We will also present techniques developed in a current SAMSI working group for improving these methods when the discretized forward model has low rank structure.