Dissertation Defense

Numerical Methods for Optimal Experimental Design of Ill-posed Problems

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Abstract: The two goals of this thesis are to develop numerical methods for solving large-scale optimal experimental design problems efficiently and to apply optimal experimental design ideas to applications in regularization techniques and geophysics.

The thesis can be divided into three parts. In the first part, we consider the problem of experimental design for linear ill-posed inverse problems. The minimization of the objective function in the classic A-optimal design is generalized to a Bayes risk minimization with a sparsity constraint. We present efficient algorithms for applications of such designs to large-scale problems. This is done by employing Krylov subspace methods for the solution of a subproblem required to obtain the experiment weights. The performance of the designs and algorithms is illustrated with a one-dimensional magnetotelluric example and an application to two-dimensional super-resolution reconstruction with MRI data.

In the second part, we find the optimal regularization for linear ill-posed problems. We propose an optimal L_2 regularization approach enabling us to obtain inexpensive and good solutions to the inverse problem. In order to reduce the computational cost, several sparsity patterns are added to the regularization operator. Numerical experiments will show that our optimal L_2 regularization approach provides much better results than the traditional Tikhonov regularization.

In the last part of the thesis, we design optimal placement of sources and receivers in a CO_2 injection monitoring. An optimal criteria is proposed based on a target zone and different treatments for placing sources and receivers are discussed.

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