THE UNIVERSITY OF CHICAGO

Department of Statistics

DISSERTATION PRESENTATION AND DEFENSE

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On the Application, Theory and Computation of Optimal Experimental Design in the Context of Sensor Placement

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ABSTRACT

Optimal experimental designs are a class of experimental designs that are optimal with respect to some statistical criterion. Sensor placement is a sampling decision on data collection which aims to minimize the uncertainty in parameter estimation. This thesis focuses on two fundamental elements: the selection of sensor locations under statistically optimal conditions, and the computation of sensor placement with an efficient algorithm.

We first present a design of experiments framework for sensor placement in a natural gas pipeline system where the dynamics are described by partial differential equations, and apply sum-up rounding strategy as a heuristic to determine the sensor locations. We continue to develop convergence theory on sum-up rounding for Bayesian inverse problems, where the direct relationship is described through a discretized integral equation. We show that the integer solution from sum-up rounding is asymptotically optimal in the limit of increasingly refined meshes, for different experimental design criteria (A- and D- optimal), and demonstrate its superior performance in comparison with other standard strategies.

We also propose an optimization algorithm to compute the sensor locations, based on sequential quadratic programming and Chebyshev interpolation. By providing gradient and Hessian information on the objective, we solve a sequence of quadratic programs with interior

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point method and achieves a complexity of O(n log^s(n)), while controlling the error through choosing the number of interpolation points to satisfy a user-defined precision level.
