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NADS Program Opening Workshop
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SPEAKER TITLES/ABSTRACTS

Alen Alexanderian
North Carolina State University

"Sensitivity Analysis for Forward and Inverse Uncertainty Quantification"

Global sensitivity analysis provides tools to gain insight in complex input output relationships and aids in parameter dimension reduction and model simplification. In this talk, I will focus on (i) multiscale global sensitivity analysis and (ii) sensitivity analysis for inverse problems. For the first topic, I will present ideas for efficient global sensitivity analysis in stochastic systems that admit representations in different scales. The focus will be on stochastic biochemical reaction networks. The second topic concerns recent work on hyper-differential sensitivity analysis (HDSA), which provides a framework for understanding and quantifying how the solution of an inverse problem is influenced by perturbations in the problem data. This helps in detecting model uncertainties that have a dominant impact on an inverse problem's solution. HDSA also aids in the design of experiments by identifying the measurements to which the inverse problem solution is most sensitive.

Bo An
Nanyang Technological University

"Reinforcement Learning in Competitive Environment"

For some complex domains with strategic interaction, reinforcement learning have been successfully used to learn efficient policies. This talk will discuss key techniques behind these success and their applications in domains including games, e-commerce, and urban planning.

Jonathan Bardsley
University of Montana

"Marginalization-Based MCMC Methods for Hierarchical Inverse Problems"

In this talk, I will present a basic hierarchical model for Bayesian inverse problems together with several MCMC methods for sampling from the resulting posterior density function. The marginal density is the probability density that results when the unknown in the inverse problem of interest is integrated from the posterior density. It is a low dimensional probability density function that depends only upon the remaining scalar parameters in the hierarchical model. For linear inverse problems, the marginal density can be computed analytically and sampled from using standard MCMC methods. In large-scale cases, however, an approximate marginal density may be needed. I will present one such approximate marginal density that takes advantage of low-rank matrix approximations. Another case in which an approximate marginal density is needed is when the inverse problem is nonlinear. I will present an approximate marginal density for nonlinear inverse problems that makes use of randomize-then-optimize within an importance sampling framework. The use of either of these approximate marginal densities requires the development of new MCMC methods. I will present a few such methods and test their performance on standard examples from inverse problems.

Julianne Chung
Virginia Tech University

Computational Advancements in Large-Scale Inverse Problems

In this talk, we describe some recent advancements in hybrid iterative methods for computing solutions to large-scale inverse problems. Hybrid iterative methods have desirable properties of (1) avoiding semi-convergence, whereby later reconstructions are no longer dominated by noise, and (2) enabling adaptive and automatic regularization parameter selection. We will describe some of the main computational challenges and advancements in this area and give some examples (e.g, from dynamic photoacoustic tomography, space-time deblurring, and passive seismic tomography) to demonstrate the range of applicability and effectiveness of these approaches.

Petros Drineas
Purdue University

“Randomization in Numerical Linear Algebra (RandNLA)”

The introduction of randomization in the design and analysis of algorithms for matrix computations (such as matrix multiplication, regression, the Singular Value Decomposition (SVD), etc.) over the past 20 years provided a new paradigm and a complementary perspective to traditional numerical linear algebra approaches. These novel approaches were motivated by technological developments in many areas of scientific research that permit the automatic generation of Big Data, which are often modeled as matrices. In this talk, we will primarily focus how such approaches can be used to design fast algorithms for Principal Components Analysis as well as fast solvers for least-squares problems, ridge-regression problems, and even linear programs.

Thierry Klein
Institut de Mathématiques de Toulouse; UMR5219. Université de Toulouse; ENAC - Ecole Nationale de l’Aviation Civile , Université de Toulouse, France

“10 Years of Sensitivity Analysis in Toulouse”

We consider a black-box code f from E := E1 x E2 x…x Ed valued in some separable metric space (X; d). The output is denoted by Z given by

Z = f(X(1); … ;X(d)).

In this survey talk we will present some of the work done in Toulouse around sensitivity analysis. This talk will be divided into the 6 following parts

1. The classical Sobol indices when X = R definition and the Pick Freeze estimation scheme [7, 4]
2. Vectorial Sobol indices for X = Rk (see [8, 1])

3. Sensitivity indices taking into account the whole distribution and not only the variance: the Cramér von Mises indices [5].
4. Sensitivity Indices for General Metric spaces [3, 6, 2]: application to code whose output are cumulative distribution functions or densities
5. Sensitivity analysis for stochastic codes [2]: application to second level sensitivity analysis

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Per-Gunnar Martinsson
University of Texas, Austin

"Randomized Algorithms for Computing Full and Partial Factorizations of Matrices"

The talk will describe how randomized projections can be used to effectively, accurately, and reliably solve important problems that arise in data analytics and large scale matrix computations. We will focus in particular on accelerated algorithms for computing full or partial matrix factorizations such as the eigenvalue decomposition, the QR factorization, etc. randomized projections are used in this context to reduce the effective dimensionality of intermediate steps in the computation. The resulting algorithms execute faster on modern hardware than traditional algorithms, and are particularly well suited for processing very large data sets.

The algorithms described are supported by a rigorous mathematical analysis that relies on recent work in random matrix theory. The talk will briefly review some representative theoretical results.

Susan Murphy
Harvard University

“Intelligent Pooling:Practical Thompson Sampling for mHealth”

In mobile health (mHealth) smart devices deliver behavioral treatments repeatedly over time to a user with the goal of helping the user adopt and maintain healthy behaviors. Reinforcement learning appears ideal for learning how to optimally make these sequential treatment decisions. However, significant challenges must be overcome before reinforcement learning can be effectively deployed in a mobile healthcare setting. In particular, individuals who are in the same context can exhibit differential response to treatments yet only a limited amount of data is available for learning on any one individual. To address these challenges we generalize Thompson-Sampling bandit algorithms to develop Intelligent Pooling. Intelligent Pooling uses empirical Bayes methods to update each userâ€™s degree of personalization while making use of available data on other users to speed up learning. In this talk we discuss associated computational challenges.