Monday, January 9, 2017

7:00 - 8:00 Breakfast

8:00 - 8:30 Welcome LANL & Theoretical Division & Analytics, Intelligence, and Technology Division, & CNLS Center Leader

8:30 – 9:30 Lecture 1/1- Michael Chertkov, Los Alamos National Laboratory; *Graphical Models for Inference and Optimization over Physical Network Flows*

We review in these lectures foundations and recent developments of Graphical Models approach of Statistical Inference originated from Information Theory, Computer Science, Artificial Intelligence and Machine Learning. We also describe applications of the approach to problems in optimization and control of network flows constrained by physics. We illustrate these applications on examples from the electric power and natural gas networks.

9:30 - 9:45 Break

9:45 – 10:45 Lecture 1/2- Michael Chertkov, Los Alamos National Laboratory; *Graphical Models for Inference and Optimization over Physical Network Flows*

10:45 - 11:00 Break

11:00 – 12:00 Lecture 2/1- Jean B. Lasserre, LAAS-CNRS, France; *The moment-SOS approach in and outside optimization*

We first provide a brief description of the moment-SOS (sum-of-squares) approach in global polynomial optimization which is based on powerful positivity certificates from real algebraic geometry. If combined with semidefinite programming (an efficient technique from convex optimization) it allows to define a hierarchy of convex relaxations for polynomial optimization problems. Each relaxation of the hierarchy is a semidefinite program whose size increases in the hierarchy and the associated monotone sequence of optimal values converges to the global optimum. Finite convergence is generic and fast in practice.

In fact this methodology also applies to solve the Generalized Problem of Moments (GPM) (of which global optimization is only a particular instance, and even the simplest). Then we briefly describe its application to several of many other applications outside optimization, notably in applied mathematics, probability, statistics, computational geometry, control and optimal control.

12:00 - 12:15 Break

12:15 - 1:15 Lecture 2/1- Jean B. Lasserre, LAAS-CNRS, France; *The moment-SOS approach in and outside optimization*

1:15 - 3:00 Lunch

3:00 - 4:00 Lecture 3/1- Laurent El Ghaoui, UC Berkeley; *Some applications of data science in smart energy applications*

I will provide a review of my recent work in the area of smart energy, all involving machine learning and optimization models. A first application involves a complex energy system, which we seek to design or improve, but only have at our disposal a very complex simulation model for it. I describe a method that builds "optimization-friendly" surrogate (ie, approximate) models, based on sparse machine learning, and an example involving a set of buildings to be renovated for better energy efficiency. A second application deals with the intra-day management of energy systems, and this time the challenge is to build an "uncertainty model" to describe future demand, and apply this model in a robust optimization context. Lastly I will evoke how text analytics can play a key role in descriptive and predictive maintenance, based on technicians reports.

4:00 - 4:15 Break

4:15 - 5:15 Lecture 3/2- Laurent El Ghaoui, UC Berkeley; *Some applications of data science in smart energy applications*

6:30 - 8:00 Dinner

Tuesday, January 10, 2017

7:00 - 8:30 Breakfast

8:30 - 9:30 Lecture 4/1- Konstantin Turitsyn, MIT; *Inner approximations of power system feasibility and stability regions*

Relaxations of power flow equations provide a natural way to construct an outer approximation of feasibility region. At the same, there are no simple ways of constructing inner approximations of feasibility and stability. The need in inner approximations arises in a variety of applications, including security assessment, emergency control and analysis of system robustness to uncertainty. In this lecture I will first introduce the applications and pose the formal problem of constructing inner approximations. Second, I will review the historical and more recent approaches including the new techniques by proposed by our group and our colleagues. I will establish known connections to monotonicity theory and discuss the dynamic problem setting corresponding to characterization of small-signal and transient stability regions. The talk will conclude with numerical demonstrations and outlook into open problems.

9:30 - 9:45 Break

9:45 - 10:45 Lecture 4/2- Konstantin Turitsyn, MIT; *Inner approximations of power system feasibility and stability regions*

10:45 - 11:00 Break

11:00 - 12:00 Lecture 5/1- Mihailo R. Jovanoivic, University of Southern California; *Controller Architectures: Tradeoffs between Performance and Complexity*

This talk describes the design of controller architectures that achieve a desired tradeoff between performance of distributed systems and controller complexity. Our methodology consists of two steps. First, we design controller architecture by incorporating regularization functions into the optimal control problem and, second, we optimize the controller over the identified architecture. For large-scale networks of dynamical systems, the desired structural property is captured by limited information exchange between physical and controller layers and the regularization term penalizes the number of communication links. In the first step, the controller architecture is designed using a customized proximal augmented Lagrangian algorithm. This method exploits separability of the sparsity-promoting regularization terms and transforms the augmented Lagrangian into a form that is continuously differentiable and can be efficiently minimized using a variety of methods. Although structured optimal control problems are, in general, nonconvex, we identify classes of convex problems that arise in the design of symmetric systems, undirected consensus and synchronization networks, optimal selection of sensors and actuators, and decentralized control of positive systems. Wide-area control of power systems will be used as a case study to demonstrate the effectiveness of the framework.

12:00 - 12:15 Break

12:15 – 1:15 Lecture 5/2- Mihailo R. Jovanoivic, University of Southern California; *Controller Architectures: Tradeoffs between Performance and Complexity*

1:15 - 3:00 Lunch

3:00 - 4:00 Lecture 6/1- Jeff Linderoth, University of Wisconsin; *Mixed-Integer Nonlinear Optimization: Applications, Algorithms, and Computation*

Mixed-integer nonlinear programming problems (MINLPs) combine the combinatorial complexity of discrete decisions with the numerical challenges of nonlinear functions. In this these talks, we will describe applications of MINLP in science and engineering, demonstrate the importance of building "good" MINLP models, discuss numerical techniques for solving MINLP, and survey the forefront of ongoing research topics in this important and emerging area.

4:00 - 4:15 Break

4:15 - 5:15 Lecture 6/2- Jeff Linderoth, University of Wisconsin; *Mixed-Integer Nonlinear Optimization: Applications, Algorithms, and Computation*

6:30 - 9:00 Poster Session and Dinner

Wednesday, January 11, 2017

7:00 - 8:30 Breakfast

8:30 – 9:30 Lecture 7/1- Marc Vuffray & Sidhant Misra, Los Alamos National Laboratory; *Learning Structured Probability Distributions from Data*

During this lecture we introduce the concept of Markov Random Field (MRF), a canonical language for representing network-structured distributions, and we present techniques to learn efficiently MRFs from data.

MRFs are multivariate probability distributions for which direct dependencies between random variables are captured by a network. MRFs are widely used for uncertainty management, inference and model reductions. In many applications the network of a MRF is expected to be sparse i.e. the number of edges is of the same order than the number of nodes. As MRFs are often not known a priori or cannot always be deduced from first principles, it is of importance to learn MRFs from data. In this lecture we focus on efficient methods for learning MRFs over discrete random variables and Gaussian random variables when data take the form of several independent observation of random variables. Alongside with the concepts related to MRFs we present several techniques and ideas coming from the world of high-dimensional stochastic optimization.

9:30 - 9:45 Break

9:45 – 10:45 Lecture 7/2- Marc Vuffray & Sidhant Misra, Los Alamos National Laboratory; *Learning Structured Probability Distributions from Data*

10:45 - 11:00 Break

11:00 – 12:00 Lecture 8/1- Art B. Owen, Stanford University; *Adaptive Importance Sampling*

Importance sampling is a method for reducing the variance of Monte Carlo computations. It is usually applied to problems where the expectation of interest is dominated by a contribution from a critical region of space that has small probability. Rare event probabilities or integrals of spiky functions are typical examples. Such problems arise in high energy physics, Bayesian computation, engineering reliability, insurance, and graphical rendering among other areas.

The method replaces the nominal sampling distribution, p, by another one, q, that takes more samples from within the critical region. The resulting bias is then corrected by a weighting the sample value by the ratio p/q. Importance sampling is often the only variance reduction method with any chance of yielding an effective Monte Carlo estimate. It is by far the most difficult variance reduction method to use in practice and it can backfire yielding a large or even infinite sampling variance, especially when the ratio p/q has high variance.

In adaptive importance sampling, we use the data we have generated to improve upon an initial choice of q. This talk first reviews importance sampling and methods for choosing q (mixtures, exponential tilting, Gaussian/Laplace approximations). Then it considers defensive and multiple importance sampling, and combinations with control variates. Then adaptive importance sampling methods are discussed, including the cross-entropy method, exponential convergence of Markov chain importance samplers, Vegas, Miser, Divonne, sampling from mixtures of products of beta distributions, adaptive multiple importance sampling (AMIS), and more recent methods.

12:00 - 12:15 Break

12:15 – 1:15 Lecture 8/2- Art B. Owen, Stanford University; *Adaptive Importance Sampling*

1:15 - 3:00 Lunch

3:00 – 4:00 Lecture 9/1- Alexandre Proutirere, KTH; *Recent Advances in Bandit Optimization*

Multi-Armed Bandit (MAB) problems constitute the most fundamental sequential decision problems with an exploration vs. exploration trade-off. In such problems, the decision maker selects an arm or action in each round, and observes the corresponding reward. The objective is to maximize the expected cumulative reward over some time horizon by balancing exploitation (actions with the highest observed rewards so far should be selected often) and exploration (all actions should be explored). MAB problems have found applications in many disciplines including medical treatment, communication systems, online services, economics, and physics. This lecture provides a survey of recent advances in bandit optimization, and of the mathematical tools used to devise algorithms and analyze their performance. We also highlight important open problems.

4:00 - 4:15 Break

4:15 – 5:15 Lecture 9/2- Alexandre Proutirere, KTH; *Recent Advances in Bandit Optimization*

6:30 – 8:00 Dinner