ISyE 6664

Stochastic Optimization

Fall 2009

Administrative Info

Instructor: Anton J. Kleywegt
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Class Room: IC 207
Class Times: Tuesday, Thursday 1:35–2:55

Description:
The course covers a variety of topics in stochastic optimization. To begin with, some approaches to optimization with uncertainty are illustrated. This course focuses on the stochastic optimization approach. Some topics in static (single stage) stochastic optimization are covered. Thereafter the course covers dynamic (multi-stage) stochastic optimization. This includes a brief overview of two-stage and multistage stochastic programs. Thereafter we move on to the dynamic programming (Markov decision process) approach, covering both finite and infinite horizon problems. Some results that apply particularly to deterministic DP are developed along the way. Special topics include problems with imperfect state information, and approximation methods for large-scale problems. Several computational techniques and applications are presented.

Objectives of the course are

- to develop an understanding of the types of problems for which a stochastic optimization approach is useful;
- to understand the fundamental role of the process by which information becomes available in stochastic optimization problems;
- to develop insight in structural characteristics of problems that are important for understanding and computation;
- to become familiar with a variety of stochastic optimization algorithms and the issues involved in their implementation;
- to understand the limitations of these algorithms, and to become familiar with some approximation methods for dealing with large-scale problems.

Prerequisites:
Previous exposure to real analysis will be important (concepts such as supremum, infimum, convergence, contraction mapping). Calculus, linear algebra, and basics of optimization and Markov chains. Programming skills will help for the optional problems.

Textbook:

Bertsekas, D.P., *Dynamic Programming and Optimal Control*, Vols. 1 and 2, Athena Scientific, Belmont, MA, 2000.

Puterman, M.L., *Markov Decision Processes*, Wiley, New York, NY, 1994.

Shapiro, A., Dentcheva, D. and Ruszczynski, A., *Lectures on Stochastic Programming: Modeling and Theory*, SIAM, Philadelphia, 2009.

References:

Bellman, R.E., *Dynamic Programming*, Princeton University Press, Princeton, NJ, 1957.

Bellman, R.E., *Adaptive Control Processes: A Guided Tour*, Princeton University Press, Princeton, NJ, 1961.

Bellman, R.E., and Dreyfus, S.E., *Applied Dynamic Programming*, Princeton University Press, Princeton, NJ, 1962.

Benveniste, A., Métivier, M., and Priouret, P., *Adaptive Algorithms and Stochastic Approximations*, Springer-Verlag, Berlin, Germany, 1990.

Bertsekas, D.P., *Dynamic Programming and Stochastic Control*, Academic Press, New York, NY, 1976.

Bertsekas, D.P., and Shreve, S.E., *Stochastic Optimal Control: The Discrete Time Case*, Academic Press, New York, NY, 1978.

Bertsekas, D.P., *Dynamic Programming: Deterministic and Stochastic Models*, Prentice-Hall, Englewood Cliffs, NJ, 1987.

Bertsekas, D.P., and Tsitsiklis, J.N., *Neuro-Dynamic Programming*, Athena Scientific, Belmont, MA, 1996.

Birge, J. R. and Louveaux, F., *Introduction to Stochastic Programming*, Springer-Verlag, New York, NY, 1997.

Denardo, E.V., *Dynamic Programming Models and Applications*, Prentice-Hall, Englewood Cliffs, NJ, 1982.

Hinderer, K., *Foundations of Non-stationary Dynamic Programming with Discrete Time Parameter*, Springer-Verlag, Berlin, 1970.

Howard, R.A., *Dynamic Programming and Markov Processes*, MIT Press, Cambridge, MA, 1960.

Nemhauser, G.L., *Introduction to Dynamic Programming*, Wiley, New York, NY, 1966.

Ross, S.M., *Introduction to Stochastic Dynamic Programming*, Academic Press, New York, NY, 1983.

Ruszczyński, A. and Shapiro, A., *Stochastic Programming* (Handbooks in Operations Research and Management Science), Springer, 2003.

Sennott, L. I., *Stochastic Dynamic Programming and the Control of Queueing Systems*, John Wiley & Sons, New York, NY, 1999.

Topics Covered:

- Approaches to Optimization with Uncertainty
- Static (Single-Stage) Stochastic Optimization
- Dynamic (Multi-Stage) Stochastic Optimization
  - Finite Horizon Problems
    - Two-stage Stochastic Programs
    - Multi-stage Stochastic Programs
    - Stochastic Dynamic Programming
  - Infinite Horizon Problems
    - Discounted Objective
    - Long-run Average Cost Objective
- Special Topics
  - Imperfect State Information (Partially Observed) Problems
  - Dynamic Programming Approximation Methods
- Applications: Shortest Path Problem and extensions, Resource Allocation, Inventory Control, Portfolio Selection, Multi-armed Bandit, Computer Chess

Grading:
Grades will be assigned as follows:

- Homework: 20%

- Midterm exam: 40%
- Final exam: 40%

Homework:
Homework will be assigned approximately once every two weeks. You should start working on each homework early, that way you will have time to ask questions in class before the homework is due. Late homework will be accepted only in case of unavoidable occurrences, such as illness or death in the family. You are encouraged to discuss homework and learn from each other, but each person must submit his/her own work, unless the homework specifically indicates that you should work in groups. Any queries on homework grades must be submitted in writing to the instructor, together with the homework in question.

Exams:
Exams will cover material discussed in class, as well as reading assignments and homeworks. The exams will be comprehensive. The midterm exam is scheduled for Tuesday October 20, 2009, in class. The midterm exam will be closed book. Any queries on exam grades must be submitted in writing to the instructor, together with the exam in question. Missing an exam will be accommodated only in case of unavoidable emergencies, and the instructor must be notified of the emergency as soon as possible. If you cannot take an exam at the designated time or in the designated way, you should make alternative arrangements with the instructor as soon as possible.

Academic Honor Code:
It is your responsibility to familiarize yourself with the Georgia Tech Honor Code. Specifically, you must do your own work in all homework and exams; when homework is specifically assigned as group homework you may and should work with the other members of your group.