Department of Computer Science/Industrial and Systems Engineering
Spring 2010

Stochastic Programming

(CS/ISyE 719)

Lecture: Tuesday and Thursday 11AM-12:15PM 2106 Mechanical Engineering Building

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Many optimization problems involve uncertainty, where the eventual outcome depends on a future random event. Stochastic programming is concerned with using mathematical optimization to help make decisions in the presence of uncertainty.

Required Text

Alexander Shapiro, Darinka Dentcheva, and Andrzej Ruszczyński. *Lectures on Stochastic Programming – Modeling and Theory* (SIAM, 2009).

Recommend Texts

John R. Birge and Fran cois Louveaux. *Introduction to Stochastic Programming* (Springer-Verlag, 1997).

Peter Kall and Stein Wallace. *Stochastic Programming* (Wiley, 1994).

Overview

The aim of stochastic programming is to find optimal decisions in problems which involve uncertain data. This field is currently developing rapidly with contributions from many disciplines including operations research, mathematics, and probability. Conversely, it is being applied in a wide variety of subjects ranging from agriculture to financial planning and from industrial engineering to computer networks. This is a first course in stochastic programming suitable for students with a basic knowledge of linear programming, elementary analysis, and probability. We will make a broad overview of the main themes and methods of the subject. Since stochastic programs are computationally very challenging, there will be a particular emphasis in this course on implementation and tools for solving difficult stochastic programming instances.

Requirements and Grading

This course is (hopefully) *not* about getting a good grade. Instead, it should be about challenging yourself and learning about stochastic programming—one of the "hottest" topics in mathematical optimization. It won't be easy!

Problem Sets

There will be weekly or bi-weekly problem sets. You may work in groups of at most two students. On each assignment, there will a 10% bonus for working alone. There is to be *no* collaboration on the problem sets with students other than your teammate. You may only work with the same student *once* during the course of the semester.

For the problem sets, I encourage the use of reference materials, but you *must* site references.

Exam

There will be one in class midterm, and one take-home final exam. No references (other than the textbook and class notes) are allowed, and there is to be no collaboration.

Grading Scheme

The course grade will be based on a weighted average of three components:

- 20% Midterm
- 50% Problem Sets
- 30% Final Exam

I don't have a grader for this course, and I have almost 60 students in my other class, so I don't have a lot of extra time this semester. As such, I will grade some of the problems in detail, and I will scan the solutions to other problems. The problems I grade in detail will be worth 10 points, and the other problems will be worth three points. I will (hopefully) provide detailed solutions to all of the problems.

There is a penalty of 10% for each day that an assignment is late, without exception. Once I have graded and returned an assignment, that homework will no longer be accepted.

(Tentative) Chronological Syllabus

Part I: **Modeling and Mathematical Background** *Approx 5 Lectures*

Basic stochastic programming modeling concepts. Mathematical review. Formulating and solving the deterministic equivalent of stochastic programs

Readings: Chapters 1 and 7

Part II: **Stochastic Linear Programs** *Approx 5 Lectures*

Basic theory and properties of two-stage stochastic linear programming with recourse. Extensions of this theory to problems with multiple stages

Readings: Chapter 2, Chapter 3

Part III: **Sampling and Monte Carlo Methods** *Approx 4 Lectures*

Exterior sampling methods for large scale problems. Statistical inferences. Variance Reduction Techniques.

Readings: Chapter 5

In Class Midterm: February 23

Part IV: **Computational/Decomposition Methods** *Approx 4 Lectures*

The L-Shaped method. Multicut methods. Bunching and other algorithmic techniques. Stabilizing the L-Shaped method. Regularized Decomposition. SMPS format.

Readings: Handouts and Papers

Part V: **Chance Constraints** *Approx. 4 lectures*

Basic Theory of Probabilitic Constraints. Solvable cases. Sampling methods for approximating chance constraints.

Readings: Portions of Chapter 4, papers.

Part VI: **Stochastic Integer Programming** *Approx 4 Lectures*

Structure of Value function. Algorithms for two-stage stochastic IP with integer recourse – Dual decomposition, integer L-Shaped method.

Readings: Handouts and Papers

Part VII: **Risk Measures** *Approx. 2 Lectures*

Dispersion statistics, coherent risk measures.

Readings: Chapter 6

Take Home Final.: Due May 7