Spring 2012

OPIM 7400: Stochastic Dynamic Programming with Applications

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CLASS MEETINGS

Monday 5:15PM-8:15PM, KOBL 350

OFFICE HOURS

By appointments.

COURSE DESCRIPTION

Stochastic dynamic programming (also known as Markov decision process) is widely used to study problems that involve sequential decision making under uncertainty. This course covers the basic models and solution techniques for problems with finite or infinite horizon. Approximate solution techniques (approximate dynamic programming) for problems involving large state/decision spaces and/or complex dynamics over time will also be discussed. The course is geared toward students who are interested in applying these methods in research. Application domains include, among others, revenue management and pricing, manufacturing, supply chains, service systems, economics, etc.

Prerequisites: An introductory course in Optimization and Probability, or instructor consent.

COURSE MATERIAL

Course material will be distributed by email, on D2L, or in class.

REQUIRED BOOK:


REFERENCE BOOKS (NOT REQUIRED)

COURSE REQUIREMENTS

You are expected to do the readings before each session. Class time is dedicated to applications of the theoretical material. Each student is expected to lead the discussion of two papers in class. A sign-up sheet will be provided in the first class.

Regular homework assignments are designed to illustrate the principles learned in class. Homework should be done individually and handed in on time. No extensions will be accepted.

GRADING

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<th>Percentage</th>
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<tbody>
<tr>
<td>Class participation/presentations</td>
<td>25%</td>
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<tr>
<td>Homework (2 sets)</td>
<td>20%</td>
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<tr>
<td>Midterm</td>
<td>20%</td>
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<tr>
<td>Final</td>
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TOPICS (subject to change depending on student interest and the pace of the class)

1. Introduction (3 hours)

   **Readings:** Puterman (1994), Chapters 1 (skim), 2.1, 2.2, 3.1, 3.2, 3.3.

2. Finite-Horizon Markov Decision Processes. (6 hours)
   Principle of optimality; backward induction; policy evaluation

   **Readings:** Puterman (1994), Sections 4.1-4.6

3. Infinite-Horizon Discounted Problems (6 hours)
   Optimality criteria; Markov policies; value iteration; policy iteration; linear programming

   **Readings:** Puterman (1994), Sections 5.1, 5.3, 5.5, 5.6, 6.1, 6.2 (not 6.2.5), 6.3.2, 6.4.1, 6.4.2, 6.9

4. Infinite-Horizon Average Reward Problems (3 hours)
Classification of Markov decision processes; unichain models; value iteration and policy iteration; linear programming

**Readings:** Puterman (1994), sections 8.1, 8.2, 8.3 (skim), 8.4, 8.5, 8.6, 8.8

5. **Structural properties (3 hours)**
   Preservation of monotonicity and convexity properties; structural properties of the value function and the optimal solution; monotone policies; closure properties; time preservation; K-convexity in inventory problems

**Readings:** Porteus, Sections 7.1, 8.1-8.3

6. **Continuous-Time Models (6 hours)**
   Continuous-time Markov chain; discounted and average reward models

**Readings:** Puterman (1994), Chapter 11
Porteus (2002), Chapter 14

7. **Introduction to Approximate Dynamic Programming (3 hours)**
   Curse of dimensionality; simulation-based methods; mathematical programming based methods

**Readings:** Powell (2007), Chapters 1 (skim), 4 (skim)

8. **Topics in Approximate Dynamic Programming (6 hours)**
   Value function approximation; information relaxation; Lagrangian relaxation


TENTATIVE SCHEDULE

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<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1/23/12</td>
<td>Introduction</td>
<td>Sign up for paper presentation</td>
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<tr>
<td>1/30/12</td>
<td>Finite-horizon problems</td>
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<tr>
<td>2/6/12</td>
<td>Finite-horizon problems</td>
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<td>2/13/12</td>
<td>Infinite-horizon discounted problems</td>
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<td>2/20/12</td>
<td>Infinite-horizon discounted problems</td>
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<tr>
<td>2/27/12</td>
<td>Infinite-horizon average reward problems</td>
<td>First homework assigned</td>
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<tr>
<td>3/5/12</td>
<td>Structural properties</td>
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<tr>
<td>3/12/12</td>
<td>Continuous-time models</td>
<td>First homework due</td>
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<td>3/19/12</td>
<td>Midterm</td>
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<td>3/26/12</td>
<td>Spring break</td>
<td>No class</td>
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<tr>
<td>4/2/12</td>
<td>Continuous-time models</td>
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<tr>
<td>4/9/12</td>
<td>Topics in approximate dynamic programming</td>
<td>Second homework assigned</td>
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<td>4/16/12</td>
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<td>4/23/12</td>
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