ISyE 7674

Dynamic Programming

Fall 1998

Administrative Info

Instructor: Anton J. Kleywegt
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Description:
The course covers deterministic as well as stochastic dynamic programming (DP). To develop the intuition, and because some results apply specifically to deterministic DP and not to stochastic DP, we will begin with the basics of deterministic DP. This will be reinforced with an introduction to deterministic continuous time optimal control. Next stochastic DP will be introduced, covering both finite and infinite horizon problems. Special topics include problems with imperfect state information, and approximation methods for large-scale problems. Computational techniques and applications will be emphasized throughout.

The **objectives** of the course are

- to develop an understanding of the types of problems for which a dynamic programming formulation and solution methods are useful;
- to become familiar with the major DP algorithms and the issues involved in their implementation;
- to develop insight in the use of DP to establish structural characteristics of problems;
- to understand the limitations of DP algorithms, and to become familiar with some approximation methods for dealing with large-scale problems;
- to understand the fundamental role of the process by which information becomes available in dynamic optimal control problems.

Prerequisites:
Basics of optimization, calculus, linear algebra, and Markov chains. Previous exposure to real analysis will be helpful (concepts such as supremum, infimum, contraction mapping), but not essential. Programming skills will help for the optional problems.

Textbook:
No textbook is required. The books by Bertsekas and Puterman are recommended. Approximately 30% of the lecture material is based on Bertsekas, 30% on Puterman, 10% on Denardo, 10% on Bertsekas and Tsitsiklis, and 20% on journal articles.

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.

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., *Dynamic Programming and Optimal Control*, Vols. 1 and 2, Athena Scientific, Belmont, MA, 1995.

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

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.

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

Topics Covered:

- Deterministic Dynamic Programming
- Computational Methods
- Deterministic Continuous Time Optimal Control
- Stochastic Dynamic Programming
  - Finite Horizon Problems
  - Infinite Horizon Problems
- Imperfect State Information (Partially Observed) Problems
- Approximation Methods
- Applications: Shortest Path Problem and extensions, Resource Allocation, Inventory Control, Portfolio Selection, Computer Chess

Grading:
Grades will be based on assignments. Two types of problems will be given in assignments. The first type covers the basics, and these problems will be compulsory. The second type covers a variety of topics, from which you can choose problems according to individual interests. Among these will be programming problems, on which you may work in groups of two. On the remaining problems, you are expected to do your own work.