The University of Connecticut **Spring 2016**
Dept. of ECE **KRP**

ECE6108 Linear Programming and Network Flows

General Information

Instructor:
Krishna R. Pattipati
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Office hours: Thursday 10:00 AM -12:00 Noon or by appointment.

Classes: Time: Monday, 6PM-9PM, Location: OAK 110

Text and Major References:

Text: Dimitris Bertsimas and John N. Tsisiklis, Introduction to Linear Optimization, Athena Scientific, Belmont, MA, 1997.

Major References:

[BER] D. P. Bertsekas, Network Optimization, Athena Scientific, Belmont, MA, 1998.

[AMO] R.K. Ahuja, T.L. Magnanti and J.B. Orlin, Network Flows, Prentice-Hall, New York, 1993.

Course Objective

This course is designed to provide students with a thorough understanding of concepts and methods for several important classes of Linear Programming (LP) and Network Flow problems, as well as the implementation and testing of these methods in software.

Course Outline

1. **Introduction.** Classification of optimization problems, Measures of complexity of algorithms, Background on Matrix Algebra, Convex Analysis, Convex Programming Problem, LP as a special case of convex programming problem

   Reference: Text: Secs. 1.3, 1.5-1.6, 2.1-2.2; One week.

2. **Linear Programming Problems.** Examples, Graphical representation and solution, Standard, Canonical, and General forms of LP, Properties of LP

   Reference: Text: Secs. 2.3-2.6, 3.1; one week.

3. **The Revised Simplex Method.** Development of the Revised Simplex Method; Basis Updates, Storage Schemes, Round-off Errors, Decomposition Methods.

   Reference: Text: Secs. 3.2-3.8; 6.1-6.5; one and a half weeks

4. **Duality Theory.** The dual problem; Duality theorem; Optimal dual variables as marginal costs; Sensitivity Analysis; Farkas' lemma and linear equalities

   Reference: Text: Ch. 4-5; one week

5. **Dual and Primal-Dual Algorithms.** Dual simplex algorithm; Primal-dual algorithm; Application to shortest paths

   Reference: Text. Ch. 4, Class Notes; one week

6. **Shortest Path Algorithms.** Computer representation of graphs, Shortest path algorithms: Dijkstra (Label setting); Moore-Bellman-d'Esopo-Pape (label correcting), Auction; Dynamic programming equation for shortest paths, Floyd-Warshall algorithm for all pairs, Bellman-Ford algorithm, Shortest paths on acyclic graphs; Viterbi decoding

   Reference: Class Notes, Ch. 4-5 of [AMO] and Ch. 2 of [BER]; two weeks.

7. **Assignment Algorithms.** Bipartite matching problems: Auction (forward-reverse) and Jonker-Volegant algorithms; Ranked (M-best) assignment algorithms

   Reference: Class Notes, Ch. 12 of [AMO] and Ch. 7 of [BER]; One and a half weeks.

8. **Maximum Flows.** Maximum Flow in a Network, DMKM algorithm, preflow-push algorithm of Goldberg and Tarjan

   Reference: Class Notes, Ch. 6-8 of [AMO] and Ch. 3 of [BER]. One week.

9. **Minimum Cost Network Flows.** Minimum cost network flows: relaxation algorithm of Bertsekas

   Reference: Class Notes, Ch. 9-11 of [AMO] and Chs. 4-6 of [BER]. One week.

10. **Minimal Spanning Trees.** Minimal Spanning Tree (MST) algorithms; Application to centralized communication network design problem; Distributed MST algorithms

    Reference: Class Notes and Ch. 13 of [AMO]. One week.

11. **Interior Point Methods.** Affine scaling algorithm; potential reduction algorithm; primal and primal-dual path following algorithm

    Reference: Text, Ch. 9. One week.

12. **Integer Programming Formulations.** Knapsack problem; Dynamic programming, Branch-and-bound and approximation algorithms.

    Reference: Class Notes and Ch. 10 of Text. One week.

Grading:

Homework Assignments:	40%
Mid-term Take Home Exam:	20%
Review Paper Presentation:	10%
Term Project:	30%
Total	100%

Additional Information:

- Starting with **March 24** Lecture, each lecture will be divided into two parts. The first 2.5 hours will be used to present course materials, and the remaining 0.5 hour will be used for students to present reviews of recent journal publications.
- Paper reviews should be based on relevant and recent (2006 and up) journal articles from, e.g., Mathematical Programming, Mathematical Programming Studies, Operations Research, Management Science, SIAM Journal on Optimization, Journal of Optimization Theory and Applications, Computational Optimization and Applications.
- Term projects can be performed in teams of two students on relevant optimization topics. Topics could be related to research, or based on at least two recent journal articles. **Numerical implementation** and **testing** are a must.
- Term project **proposals** are due on **March 10**, presentations are scheduled on **Monday May 5** from 6 PM to 9 PM, and final reports are due on **May 5, 2016.**
- Programming can be done in any language.

References:

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[BAZ05] Mokhtar S. Bazaraa, J.J. Jarvis, and H. D. Sherali, Linear Programming and Network Flows, Wiley, 2005, third edition.

[BER87] D.P. Bertsekas, Dynamic Programming: Deterministic and Stochastic Models, Prentice-Hall, Englewood Cliffs, NJ, 1987.

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[BER98] D. P. Bertsekas, Network Optimization, Athena Scientific, Belmont, MA, 1998.

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[CHV83] V. Chvatal, Linear Programming, W.H. Freeman, 1983.

[DT97] G.B. Dantzig and M.N. Thapa, Linear Programming, 1: Introduction, Springer 1997.

[DT03] G.B. Dantzig and M.N. Thapa, Linear Programming, 2: Theory and Extensions, Springer 2003.

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[NES94] Yurii Nesterov and A. Nemirovskii, Interior-Point Polynomial Algorithms in Convex Programming, Society for Industrial and Applied Mathematics, 1994.

[PAP82] C.H. Papadimitrou and K. Steiglitz, Combinatorial Optimization: Algorithms and Complexity, Prentice-Hall, Englewood Cliffs, NJ, 1982.

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