Syllabus

IND ENG 169 Integer Optimization
Instructor: Ignacio Aravena

May 28, 2019

About this course

IND ENG 169 addresses modeling and algorithms for integer programming problems, which are constrained optimization problems with integer-valued variables. Flexibility of integer optimization formulations; if-then constraints, fixed-costs, etc. Branch and Bound; Cutting plane methods; polyhedral theory. Applications in production planning, resource allocation, power generation, network design. Alternate formulations for integer optimization: strength of Linear Programming relaxations. Algorithms for integer optimization problems. Specialized strategies by integer programming solvers.

Practical information

Contact: `iaravena@berkeley.edu`, bCourses

Office hours: Weekly, either Tuesday or Thursday (TBD), 13:30 – 15:30 hours, Etcheverry Hall 4115

Reader: Sheng Liu, `lius10@berkeley.edu`, bCourses

Lectures: Tuesdays and Thursdays, 11:00 – 12:30 hours, Cory 247

Discussion (homework Q&A): Wednesdays, 15:00 –16:00 hours, Wheeler 102

Credit: 3 units

Prerequisites:
Math 53 (Multivariate Calculus)
Math 54 (Linear Algebra and Differential Equations)
Background in a programming language (e.g. Python, Matlab, Octave, R, S, Julia, etc.)

Course objectives

- To train students in modeling of integer optimization problems.
- To acquire skills in the best modeling approach that is suitable to the practical problem at hand.
- Familiarize students in leading methodologies for solving integer optimization problems, and techniques in these methodologies.

- To train the students in the selection of appropriate techniques to be used for integer optimization problems.
- Enable the students to recognize when problems can be modeled as integer optimization problems.

Grading policy

No project option:

- Homework (bi-weekly), 25%
  - 6 assignments: 6 exercises per assignments, 5 points each
  - Homework grade: $100 \cdot \min\{1, \text{total points over 6 assignements}/150\}$
- Midterm, 30% (March 12$^{\text{th}}$, 2019)
- Final, 45% (May 16$^{\text{th}}$, 2019)

Project option:

- Homework (bi-weekly), 20%
  - 6 assignments: 6 exercises per assignments, 5 points each
  - Homework grade: $100 \cdot \min\{1, \text{total points over 6 assignements}/150\}$
- Project, 20% (May 10$^{\text{th}}$, 2019)
- Midterm, 25% (March 12$^{\text{th}}$, 2019)
- Final, 35% (May 16$^{\text{th}}$, 2019)

Program

Lecture 1 (Jan. 22$^{\text{nd}}$)
Introduction to the course. Optimization problems: parameters, variables, constraints and objective. Classes of optimization problems.

Lecture 2 (Jan. 24$^{\text{th}}$)
Formulating optimization models with integer variables. Correct formulations.

Lecture 3 (Jan. 29$^{\text{th}}$)
Computational tools for solving integer optimization models.
Homework 1 (due Feb. 8$^{\text{th}}$).

Lecture 4 (Jan. 31$^{\text{st}}$)
Formulating optimization models with integer variables. (cont.)

Lecture 5 (Feb. 5$^{\text{th}}$)
Optimality, relaxation, bounds and heuristics.

Lecture 6 (Feb. 7$^{\text{th}}$)
Simplex and barrier methods.

Lectures 7-8 (Feb. 12th, 14th)
Branch-and-bound, cutting plane and branch-and-cut methods.
Homework 2 (due Feb. 22nd).

Lectures 9-10 (Feb. 19th, 21st)
Polyhedral theory: facets and extreme points.

Lectures 11-12 (Feb. 26th, Feb. 28th)
Total unimodularity and integrality.
Homework 3 (due Mar. 8th). Midterm exam limit.

Lectures 13-14 (Mar. 5th, Mar. 7th)
Decomposition schemes: Lagrangian relaxation.

Lectures 15-16 (Mar. 12th, Mar. 14th)
Dantzig-Wolfe decomposition, Benders decomposition.
Midterm exam March 12th, 2019, 11:00 – 12:30 hours (projected). Place TBA.
Homework 4 (due Mar. 22nd).

Lectures 17-18 (Mar. 19th, Mar. 21st)
Integer stochastic optimization.

Lectures 19-20 (Apr. 2nd, Apr. 4th)
Cutting plane methods: integer and mixed-integer rounding.
Homework 5 (due Apr. 12th.)

Lectures 21-22 (Apr. 9th, Apr. 11th)
Cutting plane methods: Gomory cuts.

Lectures 23-24 (Apr. 16th, Apr. 18th)
Valid inequalities. Set packing, knapsack, lifted inequalities.
Homework 6 (due Apr. 26th).

Lectures 25-26 (Apr. 23th, Apr. 25th)
Non-linear integer programming: mixed-integer convex programming.

Lectures 27-28 (Apr. 30th, May 2nd)
Non-linear integer programming: constraint integer programming.

Final exam: May 16th, 2019, 8:00 – 11:00 hours (projected). Place TBA.

Textbooks

1. Laurence A. Wolsey. *Integer Programming.* John Wiley & Sons, New York, 1998, 264 pages, ISBN 978-0-471283-66-9.

2. Michele Conforti, Gérard Conuéjols, Giacomo Zambelli. *Integer Programming.* Springer International Publishing, New York, 2014, 456 pages, ISBN 978-3-319-11007-3.

3. Dimitri Bertsimas, John N. Tsitsiklis. *Introduction to Linear Optimization.* Athena Scientific, Belmont, Massachusetts, 1997, 608 pages, ISBN 978-1-886529-19-9.

4. Stephen Boyd, Lieven Vandenberghe. *Convex Optimization.* Cambridge University Press, Cambridge, UK, 2004, ISBN 978-0-521-83378-3.

NOTE: This document has been adapted from the original version prepared by Pr. Deepak Rajan.