Optimization Topics List

Revised March 2016

Starting in Spring 2015, we will adopt the reading list below. The format of the exam will be to answer 4 questions drawn from material in the courses CS524, CS525, CS728, and CS726.

Linear Programming

- Primal simplex method
- Dual simplex method
- Duality theory
- Parametric programming and sensitivity analysis
- Degeneracy
- Linear complementarity problems
- Convex quadratic programming
- Interior point methods

Primary references

1. M. C. Ferris, O. L. Mangasarian & S. J. Wright, *Linear Programming with MATLAB*, SIAM, 2007
2. D. Bertsimas and J. Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific, 1997
3. R. J. Vanderbei, *Linear Programming: Foundations and Extensions*, Kluwer, 1996

Integer Programming

- Methods for solving integer programs
- Complexity
- Integer programming models
- Linear inequalities and polyhedra
- Perfect formulations
- Split and Gomory Inequalities

Primary references

1. M. Conforti, G. Cornuéjols, G. Zambelli, *Integer Programming*, Springer, 2014.
2. G. Nemhauser and L.A. Wolsey, *Integer and Combinatorial Optimization*, Wiley, 1988.
3. L. A. Wolsey, *Integer Programming*, Wiley, 1998

Nonlinear Programming

- Optimality conditions: first-order conditions (including Karush-Kuhn-Tucker conditions for constrained optimization), second-order necessary and sufficient conditions
- Theorems of the alternative
- Geometry of convex sets, convex functions and their conjugates
- Unconstrained optimization theory and algorithms:

    1. first-order methods, including stochastic gradient methods
    2. line search and trust-region approaches, including conjugate-gradient
    3. Newton's method, quasi-Newton methods and variants
    4. derivative-free optimization
    5. least-squares problems

- Topics in constrained optimization

    1. Optimization with linear constraints
    2. Duality
    3. Gradient projection methods

Primary references

1. J. Nocedal and S. J. Wright, *Numerical Optimization*, 2d Ed., Springer, 2006
2. A. Ruszczynski, *Nonlinear Optimization*, Princeton, 2005.
3. S. Boyd and L. Vandenberghe, *Convex Optimization*, Cambridge University Press, 2004. (Available for download at `http://www.stanford.edu/~boyd/cvxbook/`)
4. R.T. Rockafellar, *Convex Analysis*, Princeton, 1970

Optimization Modeling

- Writing algebraic descriptions of optimization and economic models

    1. Advanced Linear modeling techniques
    2. Modeling problems as network optimization problems
    3. Modeling techniques using binary and integer variables
    4. Modeling approaches for dealing with uncertainty

- Understanding the use of a modeling language
- Understanding the impact of convexity and model strength on algorithm effectiveness

Primary references

1. A. Brooke, D. Kendrick, A. Meeraus, and R.Raman, *GAMS: A User's Guide* (available with other documentation at `http://www.gams.com/docs/document.htm`)
2. R. Fourer, D.M. Gay, and B.W. Kernighan, *AMPL: A Modeling Langauge for Mathematical Programming, 2d Ed.*, Duxbury Press, Belmont, CA, 2002.
3. H.P. Williams, *Model Building in Mathematical Programming, 4th Ed.*, Wiley, 1999.