

OPTIMIZATION TOPICS LIST

Revised October 2006

Integer Programming/Modeling

- Integer and mixed integer models
- Existence of optimal solutions, optimality conditions
- Branch and bound methods
- Cutting plane methods
- Decomposition: Lagrangian relaxation and column generation
- Local search and other heuristics

Primary references

1. G. Nemhauser and L.A. Wolsey, *Integer and Combinatorial Optimization*, Wiley, 1988
2. L. A. Wolsey, *Integer Programming*, Wiley, 1998
3. Y. Pochet and L. A. Wolsey, *Production Planning by Mixed Integer Programming*, Springer, 2006 (Chapters 3, 6-8)

Linear Programming

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

Primary references

1. D. Bertsimas and J. Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific, 1997
2. V. Chvátal, *Linear Programming*, Freeman, 1983
3. G.B. Dantzig, *Linear Programming and Extensions*, Princeton, 1963
4. M. C. Ferris, O. L. Mangasarian & S. J. Wright: "Linear Programming with MATLAB", CS 525 Lecture Notes, University of Wisconsin, Madison [Available from Division of Information Technology (DoIT)].
5. D. Gale, *The Theory of Linear Economic Models*, University of Chicago Press, 1989
6. K.G. Murty, *Linear Programming*, Wiley, 1983
7. R. J. Vanderbei, *Linear Programming: Foundations and Extensions*, Kluwer, 1996
8. S. J. Wright, *Primal-Dual Interior-Point Methods*, SIAM, 1997

Nonlinear Programming

- Optimality conditions:
 - saddlepoint
 - first-order
 - second-order
- Theorems of the alternative
- Duality
- Unconstrained optimization theory and algorithms:
 1. line search
 2. trust-region
 3. quasi-Newton
 4. conjugate-gradient
 5. derivative-free optimization
 6. least-squares problems
- Constrained optimization theory and algorithms
 1. Optimization with bound constraints
 2. Augmented Lagrangian
 3. Sequential quadratic programming
 4. Interior-point methods
 5. Penalty functions
- Stability and sensitivity

Primary references

1. D. P. Bertsekas, *Nonlinear Programming*, 2d Ed., Athena Scientific, P.O. Box 391, Belmont, MA 02178, 1999
2. R. Fletcher, *Practical Methods of Optimization*, 2d Ed., Wiley, Chichester & New York, 1987
3. P.E. Gill, W. Murray & M.H. Wright, *Practical Optimization*, Academic Press, 1981
4. O.L. Mangasarian, *Nonlinear Programming*, SIAM, Philadelphia 1994
5. J. Nocedal and S. J. Wright, *Numerical Optimization*, 2d Ed., Springer, 2006
6. B.T. Polyak, *Introduction to Optimization*, Optimization Software Inc., 1987
7. A. Ruszczyński, *Nonlinear Optimization*, Princeton, 2005.

Network Flows

- Incidence matrices for directed graphs
- Total unimodularity
- The network simplex method
- Minimum cost network problems, including matching and assignment problems and shortest path problems
- Networks with nonlinear cost functions
- Max flow - min cut and critical path problems
- Relaxation and auction algorithms

Primary references

1. R.K. Ahuja, T.L. Magnanti & J.B. Orlin, *Network Flows*, Prentice-Hall, 1993
2. M. Bazaraa, J. Jarvis & H. Sherali, *Linear Programming and Network Flows*, Wiley, 1990
3. D. Bertsekas, *Network Optimization*, Athena Scientific, 1998
4. L.R. Ford & D.R. Fulkerson, *Flows in Networks*, Princeton University Press, 1962
5. P.A. Jensen & J.W. Barnes, *Network Flow Programming*, Wiley, 1980
6. J. Kennington & R. Helgason, *Algorithms for Network Programming*, Wiley, 1980
7. R.T. Rockafellar, *Network Flows and Monotropic Optimization*, Wiley-Interscience, 1984

Tools and Environments

- Building optimization models within a modeling language
- Modeling techniques using binary and integer variables
- Large scale linear and nonlinear programming models and solution
- Visualization and interfacing optimization to applications

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 Language for Mathematical Programming*, 2d Ed. Duxbury Press, Belmont, CA, 2002
3. H. P. Williams, *Model Building in Mathematical Programming*, 4th Ed., Wiley, 1999

Variational Analysis and Convexity in Optimization

- Convex sets
- Convex functions and their conjugates
- Conjugate duality and its applications
- Variational geometry

Primary references

1. D.P. Bertsekas, *Convex Analysis and Optimization*
2. S. Boyd and L. Vandenberghe, *Convex Optimization*, Cambridge University Press, 2004. (Available for download at <http://www.stanford.edu/~boyd/cvxbook/>)
3. J.-B. Hiriart-Urruty and C. Lemaréchal, *Convex Analysis and Minimization Algorithms I, II* (2 vols), Springer-Verlag, Berlin, 1993
4. R.T. Rockafellar, *Convex Analysis*, Princeton, 1970
5. R.T. Rockafellar, *Conjugate Duality and Optimization*, SIAM, 1974
6. R.T. Rockafellar and R. J.-B. Wets, *Variational Analysis*, Springer-Verlag, Berlin, 1998 (especially Chapters 1, 2, 4, 5, 6)