Syllabus

Course description The primary focus of this course is to learn about models and algorithms used for Convex Optimization, also called convex programming. Our primary focus will be on modeling techniques and some related applications. A secondary focus will be learning necessary topics in convex analysis and applicable algorithms.


Software Matlab, CVX

The following are specific course assessment topics:

1. Convex and affine sets
   (a) Hyperplanes, halfspaces, polyhedra
   (b) Euclidean and other norm balls, elipsoids
   (c) Positive semidefinite cone
   (d) Second-order cone

2. Convexity preserving operations
   (a) Intersection
   (b) affine functions
   (c) perspective functions
   (d) linear-fractional function

3. Generalized inequalities
   (a) Proper cones
   (b) Minimum versus minimal
   (c) Supporting hyperplane theorem
   (d) Dual cones

4. Convex functions
   (a) Definition
   (b) Operations that preserve function convexity
   (c) Conjugate function
   (d) Quasiconvex
(e) log-concave/convex
(f) convex functions with generalized inequalities

5. Convex Optimization
(a) opt. problems in standard form
(b) convex opt. problems
(c) quasiconvex opt.
(d) linear opt.
(e) quadratic opt.
(f) geometric opt.
(g) generalized inequality constraints
(h) semidefinite programming
(i) vector optimization

6. Duality
(a) Lagrangian duality
(b) weak versus strong
(c) optimality conditions
(d) geometric interpretation
(e) perturbation and sensitivity analysis
(f) generalized inequalities

7. Applications
(a) Approximation and fitting
   i. norm approximation
   ii. least-norm problems
   iii. regularized approximation
   iv. robust approximation
(b) Miscellaneous
   i. multi-period processor speed scheduling
   ii. minimum time optimal control
   iii. grasp force optimization
   iv. optimal broadcast transmitter power allocation
   v. phased-array antenna beamforming
   vi. optimal receiver location
(c) Stochastic programming
   i. stochastic programming
   ii. certainty equivalent problem
   iii. penalization methods
   iv. Monte-carlo sampling methods
v. validation
(d) Chance constrained optimization
   i. chance constraints and percentile optimization
   ii. chance constraints for log-concave distributions
   iii. convex approximation of chance constraints
(e) Filter design and equalization
   i. FIR filters
   ii. Chebychev design
   iii. linear phase filter design
   iv. equalizer design
   v. filter magnitude specifications
(f) CVX, matlab
   i. using different solvers with CVX
   ii. Linear programs
   iii. Quadratic programs
   iv. Semidefinite programs
(g) $\ell_1$ methods, convex-cardinality problems
   i. Cardinality and the $\ell_1$ relaxation
   ii. Convex interpretations
   iii. Total variation
   iv. iterated weighted heuristic
   v. matrix rank constraints
(h) Statistical estimation
(i) Geometric problems
   i. extremal volume ellipsoids
   ii. centering
   iii. classification
   iv. facility location

8. Numerical linear algebra background and review
   (a) matrix structure and algorithm complexity
   (b) solving linear equations with factored matrices
   (c) LU, Cholesky, LDL factorization
   (d) matrix inversion lemma

9. Unconstrained minimization
   (a) gradient descent
   (b) steepest descent
   (c) Newton’s method
   (d) self-concordant functions