13. Conclusions

- main ideas of the course
- importance of modeling in optimization
Modeling

mathematical optimization

• problems in engineering design, data analysis and statistics, economics, management, . . . , can often be expressed as mathematical optimization problems

• techniques exist to take into account multiple objectives or uncertainty in the data

tractability

• roughly speaking, tractability in optimization requires convexity

• algorithms for nonconvex optimization find local (suboptimal) solutions, or are very expensive

• surprisingly many applications can be formulated as convex problems
Theoretical consequences of convexity

- local optima are global

- extensive duality theory
  - systematic way of deriving lower bounds on optimal value
  - necessary and sufficient optimality conditions
  - certificates of infeasibility
  - sensitivity analysis

- solution methods with polynomial worst-case complexity theory (with self-concordance)
Practical consequences of convexity

(most) **convex problems can be solved globally and efficiently**

- interior-point methods require 20 – 80 steps in practice

- basic algorithms (e.g., Newton, barrier method, . . .) are easy to implement and work well for small and medium size problems (larger problems if structure is exploited)

- more and more high-quality implementations of advanced algorithms and modeling tools are becoming available

- high level modeling tools like cvx ease modeling and problem specification
How to use convex optimization

to use convex optimization in some applied context

• use rapid prototyping, approximate modeling
  – start with simple models, small problem instances, inefficient solution methods
  – if you don’t like the results, no need to expend further effort on more accurate models or efficient algorithms

• work out, simplify, and interpret optimality conditions and dual

• even if the problem is quite nonconvex, you can use convex optimization
  – in subproblems, e.g., to find search direction
  – by repeatedly forming and solving a convex approximation at the current point
Further topics

some topics we didn’t cover:

• methods for very large scale problems

• subgradient calculus, convex analysis

• localization, subgradient, and related methods

• distributed convex optimization

• applications that build on or use convex optimization