E.T.

EFFICIENT TOOLS
for RESEARCH

YALMIP: Optimization Made Easy

2017-04-06

YALMIP: Optimization Made Easy!

and

Modeling Languages/Layers for Optimization in general

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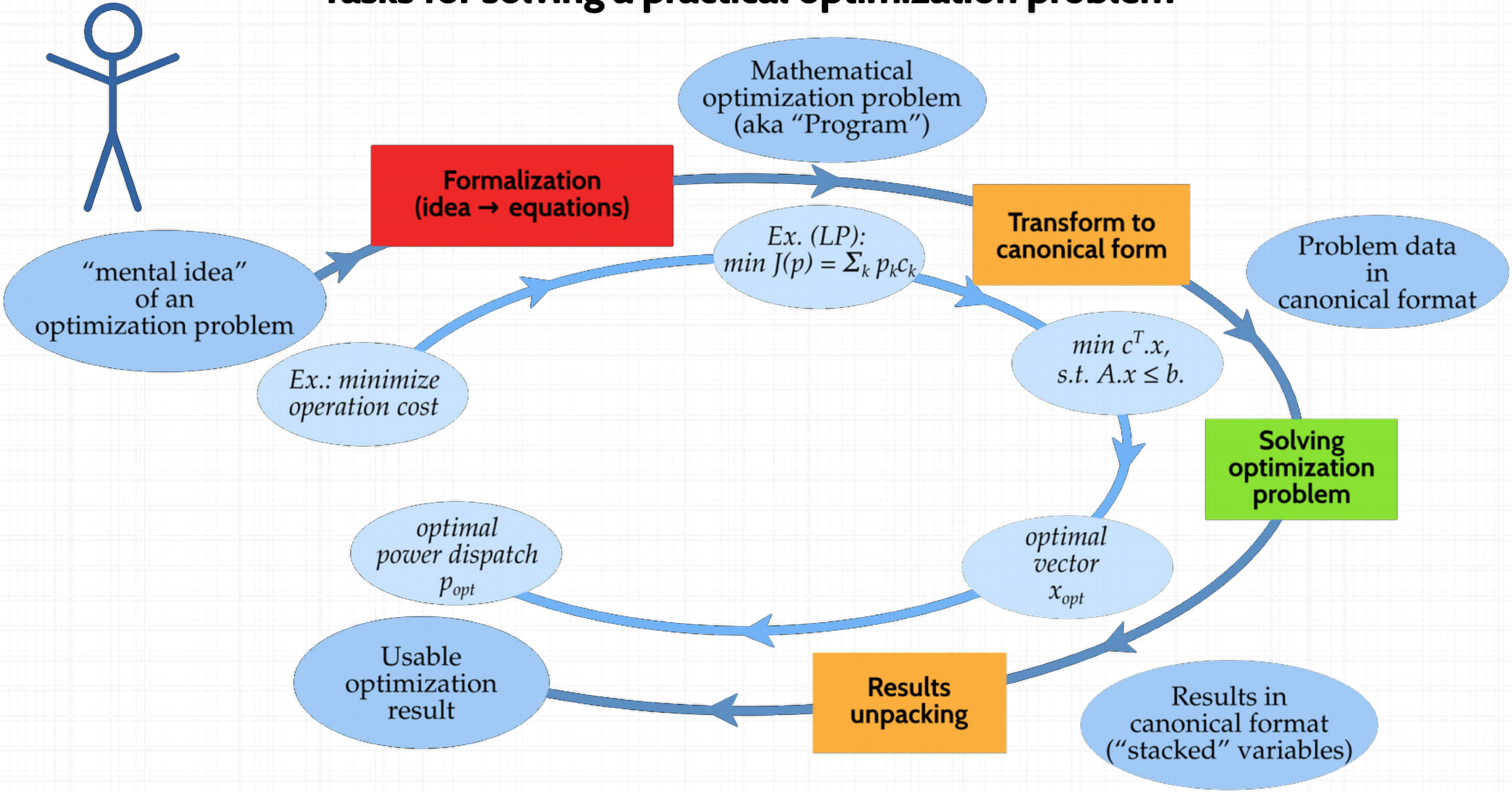
CentraleSupélec Rennes, April 6^{th}, 2017

Tasks for solving a practical optimization problem



Where is human time spent?

1) Formalize the problem into a Mathematical Optimization problem

   → **core skill** of the researcher

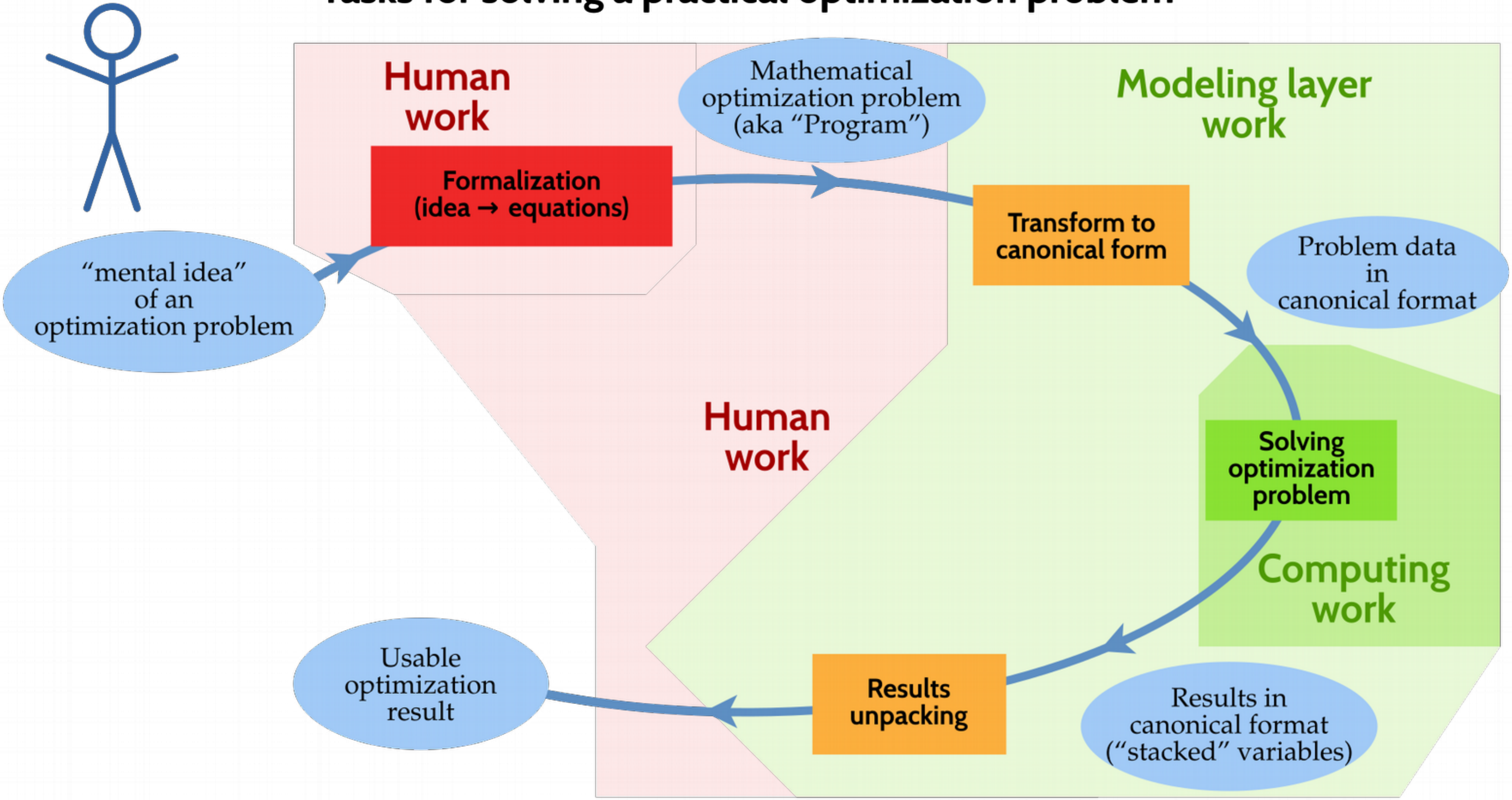
2) Transform to a canonical form (solver specific API)

   [now some computing time...]

3) Retrieve results out of the canonical format (again solver specific)

YALMIP can help the researcher focus on its **core skill**

Tasks for solving a practical optimization problem



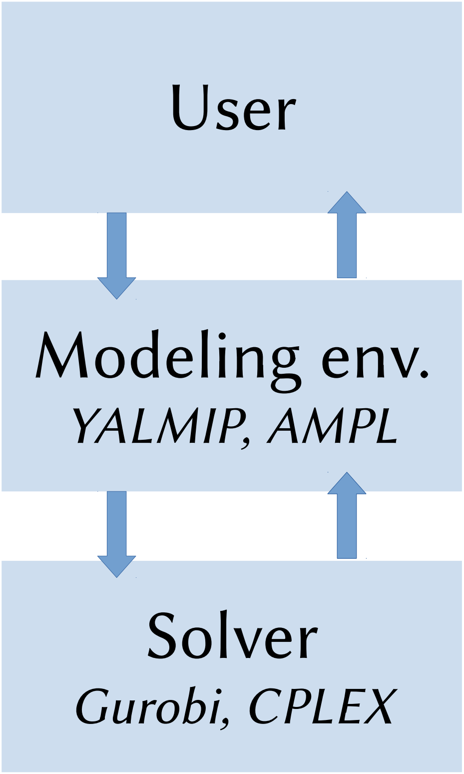
Modeling Languages/Layers for Optimization

Environment	Software/Toobox/ Package
Standalone	AMPL, GAMS (~1990)
Matlab	**YALMIP**, CVX (~ 2000)
Python	Pyomo, PuLP (MILP only), CVXPy
Julia	JuMP, Convex.jl

Relationship to the optimization solver

- When using a modeling environment, the solver is *mostly hidden* from the user.
- The choice of the modeling layer is (mostly) independent of the choice of solver.

  For ex. YALMIP provides interfaces for most common solvers:
  - Gurobi, CPLEX, MOSEK (Commercial)
  - GLPK, Ipopt, SEDUMI (Free)
  - linprog from Matlab Optimization Toolbox



Matlab Tooboxes

- **YALMIP**: 2001 – present, **J. Löfberg**
  from Linköping University, (post-doc at ETH Zürich)
  Project: https://yalmip.github.io/. Author: http://users.isy.liu.se/en/rt/johanl/

- **CVX** : 2005 – present, **M. Grant** and **S. Boyd**.
  from Stanford University
  (compatibility problem with Matlab 2017)
  - CVX Research, inc. 2012: http://cvxr.com/
  - M. Grant joined Continuum Analytics in 2015
    (platforms for Data Science, mostly Python).

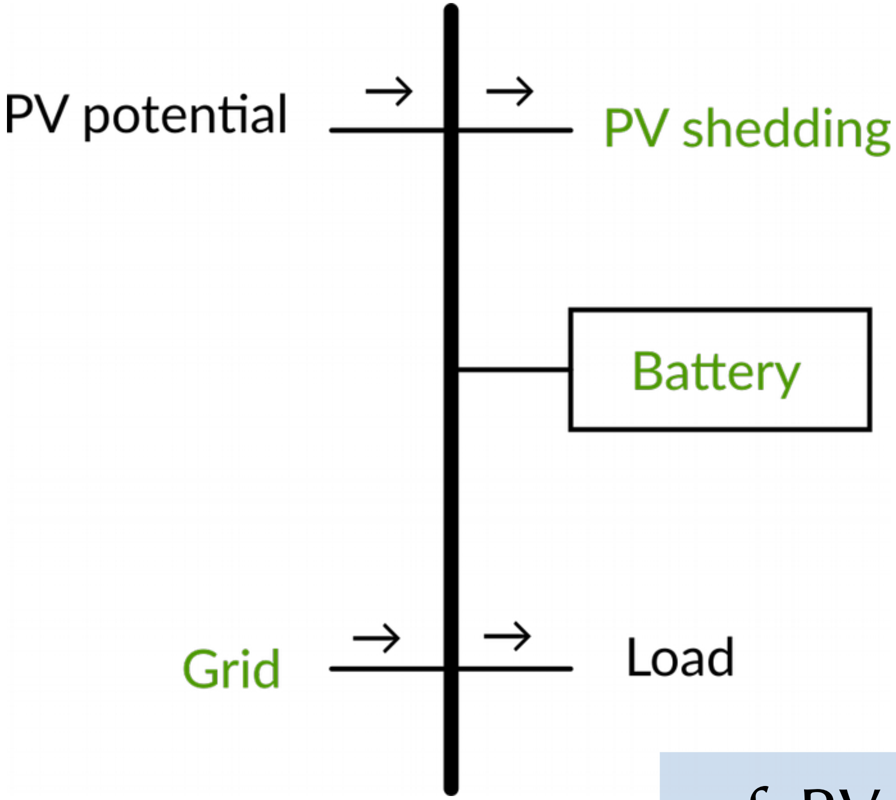
YALMIP quickstart

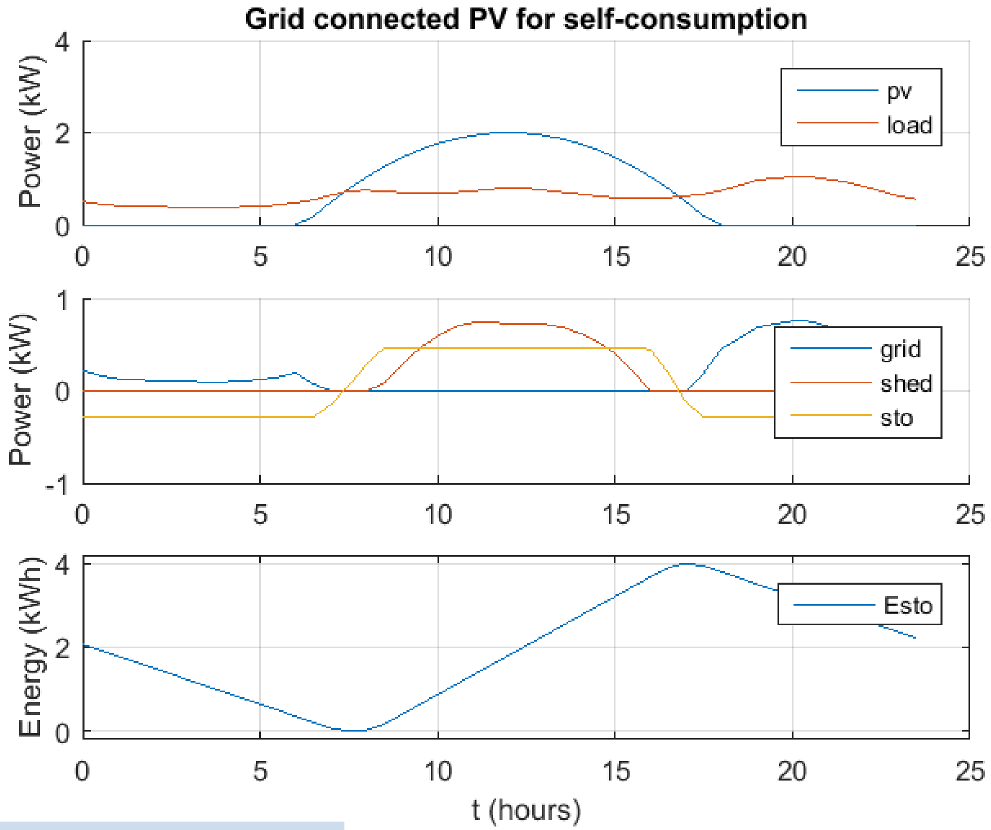
1) **Download** ZIP archive and unzip the archive in some folder.
   (https://yalmip.github.io/download/)

2) Add YALMIP folders (with subfolders) to the **MATLAB path**.
   (cf. https://yalmip.github.io/tutorial/installation/)

3) Start using it! You can look at the “Getting Started” tutorial.
   (https://yalmip.github.io/tutorial/basics/)

Demo: Grid-connected PV-storage system





cf. PVgrid.m script

Wrap up: advantages/drawbacks

Key advantages:

- Shorter starting time (for students), shorter development time
- **Increased agility** *(⟶ better research!)*
  - Quickly **compare solvers**
  - Quickly **compare different problem models** (e.g. LP vs. QP)

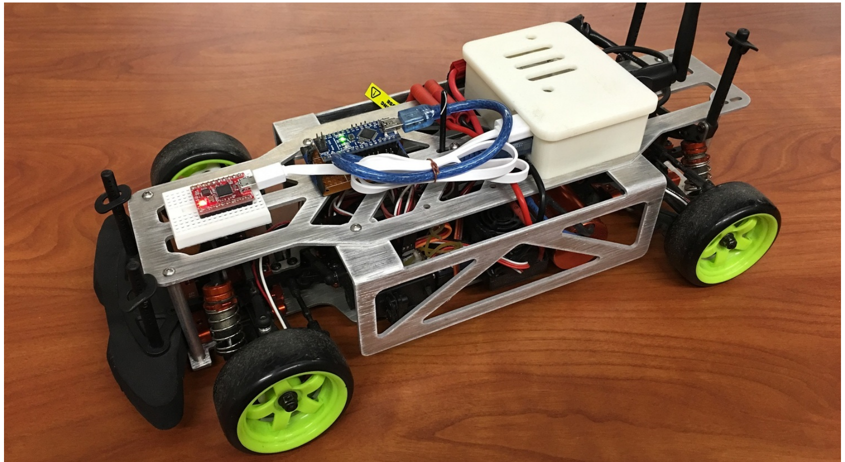
But maybe:

- Computational overhead?
  - e.g. less efficient when *recycling* the problem (like for MPC)?

Application to Embedded Optimization

Example of an **Autonomous Driving RC Car** “BARC Project”

- Implementation with Julia + JuMP *(+ ROS + ...)*
- Project pages: http://www.barc-project.com/, https://github.com/MPC-Berkeley/barc
- Presentation by Jon Gonzales (Berkeley MPC Lab) at JuliaCon 2016
  https://www.youtube.com/watch?v=bX4TXWO7dA0



Standalone commercial modeling languages

- **AMPL** (A Mathematical Programming Language) http://ampl.com/
  - started ~1985 at Bell labs
  - "AMPL Optimization LLC" spun-off in 2002.
- **GAMS** (General Algebraic Modeling System) https://www.gams.com
  - started in 1970s at the World Bank (an economic modeling group)
  - commercial product by "GAMS Developement Corp." since 1987

Some references, in chronological order

- **GAMS**: J. Bisschop and A. Meeraus, "On the development of a general algebraic modeling system in a strategic planning environment," Mathematical Programming Studies, vol. 20, p. 1–29, **1982**.
- **AMPL**: R. Fourer, D. M. Gay, and B. W. Kernighan, "A Modeling Language for Mathematical Programming," Management Science, vol. 36, no. 5, p. 519–554, **1990**.
- **YALMIP**: J. Löfberg, "YALMIP : a toolbox for modeling and optimization in MATLAB," in *2004 IEEE International Conference on Robotics and Automation*, **2004**.
- **CVX**: M. Grant and S. Boyd, "Graph Implementations for Nonsmooth Convex Programs", in *Recent Advances in Learning and Control (tribute to M. Vidyasagar),* V. Blondel, S. Boyd, and H. Kimura, editors, Springer, **2008**, pp. 95-110.