The R package **cccp**: Design for solving cone constrained convex programs

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R in Finance
16 – 17 May 2014
Chicago

Contents

Motivation

- Only a few R packages available for solving convex problems with cone constraints (non-negative orthant, second-order cone and/or semidefinite programming).
- Some of these packages are APIs to (commercial) solver suites and/or are not platform-independent, *e.g.*, **cplexAPI**, **Rcplex**, **Rmosek** and **Rcsdp**.
- Therefore, developing and providing a package for solving cone constrained convex progams will fill a niche in Rs optimization landscape.

Convex Programs

- General formulation:

$$\begin{aligned} &\text{minimize } f_0(\mathbf{x}) \\ &\text{subject to } f_i(\mathbf{x}) \preceq_{K_i} 0\,, i = 1, \ldots, m \\ &A\mathbf{x} = b\,, \end{aligned} \tag{1}$$

whereby $f_0(\mathbf{x}) : \mathfrak{R}^n \to \mathfrak{R}$ is convex, $f_i(\mathbf{x}) : \mathfrak{R}^n \to \mathfrak{R}^{K_i}$ are inequality constraints with respect to a cone K_i and $A \in \mathfrak{R}^{p \times n}$ and b represent equality constraints with $rk(A) = p$ (see Andersen et al., 2011; Boyd and Vandenberghe, 2009).

- This formulation includes for instance LPs (*e.g.* with SOC constraints), QPs (*e.g.* with quadratic constraints), SDPs, GPs and general nonlinear convex optimization problems.

Design I

- Implementation in R with interface (module) to C++.
- Employment of S4-classes/methods (with validation/unit testing, where applicable).
- Dependencies: **Matrix** (Bates and Mächler, 2013), **numDeriv** (Gilbert and Varadhan, 2012), **Rcpp** (Eddelbuettel and François, 2011; Eddelbuettel, 2013), **RcppEigen** (Bates and Eddelbuettel, 2013),and **RUnit** (Burger et al., 2010) (Burger et al., 2010), **rbenchmark** (Kusnierczyk, 2012) (suggests).
- Make (limited) use of matrix structure (diagonal, dense, sparse) by means of facilities offered in **Matrix** and/or **RcppEigen**.
- Main function `cccp()`; in its body:
  1. Create S4-class object `CPD` of program definition.
  2. Apply generic optimization method `cps()` to `CPD`.
  3. Return object of S4-class `CPS`.

Design II

- Inequality constraints provided as a `list` object with objects of cone S4-classes: paves way for parallel processing.
- Generics/methods for log-barrier functions and Nesterov-Todd scalings defined for the first and second derivatives of NNO-, SOC- and PSD constraints.
- Generics/methods: `pobj`, `dobj`, `rprim`, `rcent`, `rdual`, *etc*.

Outlook

- Still work in progress and package development at α-stage.
- Updates on: `http://r-forge.r-project.org`; project `cccp`.
- View this lightning talk as an announcement.
- More to tell/share/show at next year's R in Finance.

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