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

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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 programs will fill a niche in Rs optimization landscape.
Convex Programs

- **General formulation:**

\[
\begin{align*}
\text{minimize } & \quad f_0(x) \\
\text{subject to } & \quad f_i(x) \preceq_{K_i} 0, \quad i = 1, \ldots, m \\
& \qquad A x = b,
\end{align*}
\]

whereby \( f_0(x) : \mathbb{R}^n \to \mathbb{R} \) is convex, \( f_i(x) : \mathbb{R}^n \to \mathbb{R}^{K_i} \) are inequality constraints with respect to a cone \( K_i \) and \( A \in \mathbb{R}^{p \times n} \) and \( b \) represent equality constraints with \( \text{rk}(A) = p \) (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 1

- 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.
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.
Still work in progress and package development at \( \alpha \)-stage.

Updates on: \texttt{http://r-forge.r-project.org}; project \texttt{cccp}.

View this lightning talk as an announcement.

More to tell/share/show at next year’s R in Finance.
Bibliography


