

Package ‘cccp’

December 9, 2023

Version 0.3-1

Date 2023-12-09

Title Cone Constrained Convex Problems

Maintainer Bernhard Pfaff <bernhard@pfaffikus.de>

Depends R (>= 3.0.1), methods

Suggests RUnit, numDeriv

LazyLoad yes

Description

Routines for solving convex optimization problems with cone constraints by means of interior-point methods. The implemented algorithms are partially ported from CVXOPT, a Python module for convex optimization (see <<https://cvxopt.org>> for more information).

Imports Rcpp (>= 0.11.2)

LinkingTo Rcpp, RcppArmadillo

License GPL (>= 3)

RcppModules CPG

NeedsCompilation yes

Author Bernhard Pfaff [aut, cre],
Lieven Vandenberghe [cph] (copyright holder of cvxopt),
Martin Andersen [cph] (copyright holder of cvxopt),
Joachim Dahl [cph] (copyright holder of cvxopt)

Repository CRAN

Date/Publication 2023-12-09 17:50:02 UTC

R topics documented:

cccp	2
CPD-class	3
CPG	3
cps	4
ctrl	5
dcp	6

dlp	7
dnl	7
dqp	8
getFoo	9
gp	10
ll	11
nlfc	11
nnoc	12
psdc	12
Rcpp_CONEC-class	13
Rcpp_CPS-class	13
Rcpp_CTRL-class	14
Rcpp_DCP-class	14
Rcpp_DLP-class	15
Rcpp_DNL-class	15
Rcpp_DQP-class	16
Rcpp_PDV-class	16
rp	17
socc	17

Index 19

cccp *Solving linear and quadratic programs with cone constraints*

Description

This function is the main function for defining and solving convex problems in the form of either linear or quadratic programs with cone constraints.

Usage

```
cccp(P = NULL, q = NULL, A = NULL, b = NULL, cList = list(),
     x0 = NULL, f0 = NULL, g0 = NULL, h0 = NULL,
     nlfList = list(), nlgLList = list(), nlhList = list(),
     optctrl = ctrl())
```

Arguments

P	An object of class <code>matrix</code> with dimension $N \times N$ or <code>NULL</code> .
q	An object of class <code>vector</code> with dimension $N \times 1$ or <code>NULL</code> .
A	An object of class <code>matrix</code> with dimension $p \times N$.
b	An object of class <code>vector</code> with dimension $p \times 1$.
cList	A list object containing the cone constraints. Elements must be of either S4-class <code>NNOC</code> , or <code>SOCC</code> , or <code>PSDC</code> .
x0	An object of class <code>vector</code> with dimension $n \times 1$ for the initial values. The point <code>x0</code> must be in the domain of the nonlinear constraints.

<code>f0</code>	function: the scalar-valued convex and twice-differentiable objective function (its first argument must be 'x').
<code>g0</code>	function: the gradient function of the objective (its first argument must be 'x').
<code>h0</code>	function: the Hessian function of the objective (its first argument must be 'x').
<code>nlfList</code>	A list object containing the nonlinear constraints as its elements. The functions have to be specified with <code>x</code> as their first argument and must be casted in implicit form, <i>i.e.</i> $f(x) \leq 0$.
<code>nlgLst</code>	A list object containing the gradient functions as its elements. The functions have to be specified with <code>x</code> as their first argument.
<code>nlhList</code>	A list object containing the Hessian functions as its elements. The functions have to be specified with <code>x</code> as their first argument.
<code>optctrl</code>	An object of S4-class <code>Rcpp_CTRL</code> .

Value

An object of class `Rcpp_CPS`.

CPD-class

Class "CPD"

Description

Class union of `Rcpp_DLP`, `Rcpp_DQP`, `Rcpp_DCP` and `Rcpp_DNL`.

Objects from the Class

A virtual Class: No objects may be created from it.

Methods

No methods defined with class "CPD" in the signature.

CPG

Rcpp module: CPG

Description

Module for defining and solving convex programs.

Details

The module contains the following items: classes:

CONEC Class for inequality (cone) constraints.

CTRL Class for control parameters used in optimizations.

PDV Class for primal/dual variables.

DCP Class for definition of convex programs.

DLP Class for definition of linear programs.

DNL Class for definition of linear programs with non-linear constraints.

DQP Class for definition of quadratic programs.

CPS Class for solution of convex programs.

functions:

rpp Function for solving risk parity portfolios.

gpp Function for solving a geometric program.

cps

Solving a convex program

Description

This function returns an optimal point for a cone constraint convex program.

Usage

```
## S4 method for signature 'Rcpp_DCP,Rcpp_CTRL'
cps(cpd, ctrl)
## S4 method for signature 'Rcpp_DLP,Rcpp_CTRL'
cps(cpd, ctrl)
## S4 method for signature 'Rcpp_DNL,Rcpp_CTRL'
cps(cpd, ctrl)
## S4 method for signature 'Rcpp_DQP,Rcpp_CTRL'
cps(cpd, ctrl)
```

Arguments

cpd	An object belonging to the class union CPD.
ctrl	An object of reference-class Rcpp_CTRL.

Value

An object of reference-class Rcpp_CPS.

`ctrl`*Creating objects of reference-class CTRL*

Description

This function creates an object of reference-class CTRL which contains optimization parameters, *e.g.* the maximum number of iterations.

Usage

```
ctrl(maxiters = 100L, abstol = 1e-06, reltol = 1e-06,  
     feastol = 1e-06, stepadj = 0.95, beta = 0.5, trace = TRUE)
```

Arguments

<code>maxiters</code>	integer, the maximum count of iterations.
<code>abstol</code>	numeric, the absolute level for convergence to be achieved.
<code>reltol</code>	numeric, the relative level for convergence to be achieved.
<code>feastol</code>	numeric, the feasible level for convergence to be achieved.
<code>stepadj</code>	numeric, step size adjustment in combined step.
<code>beta</code>	numeric, parameter in backtracking line search.
<code>trace</code>	logical, if TRUE (the default), the solver's progress during the iterations is shown.

Value

An object of reference-class CTRL.

Note

Either `abstol` or `reltol` can be set to a negative real number. `feastol` must be greater than zero.

See Also

[Rcpp_CTRL](#)

dcp

*Creating a member object of the reference-class DCP***Description**

This function returns an object containing the definition of a convex program with non-linear constraints and (if provided) cone constraints. The returned object is a member of the reference-class DCP.

Usage

```
dcp(x0, f0, g0, h0, cList = list(), nlfList = list(), nlgList = list(),
    nlhList = list(), A = NULL, b = NULL)
```

Arguments

<code>x0</code>	An object of class <code>vector</code> with dimension $n \times 1$ for the initial values. The point <code>x0</code> must be in the domain of the nonlinear constraints.
<code>f0</code>	function: the scalar-valued convex and twice-differentiable objective function (its first argument must be 'x').
<code>g0</code>	function: the gradient function of the objective (its first argument must be 'x'); returning a vector.
<code>h0</code>	function: the Hessian function of the objective (its first argument must be 'x'); returning a matrix.
<code>cList</code>	A list object containing the cone constraints. Elements must be of either S4-class <code>NNOC</code> , or <code>SOCC</code> , or <code>PSDC</code> or an empty list in case of no inequality constraints.
<code>nlfList</code>	A list object containing the nonlinear constraints as its elements. The functions have to be specified with <code>x</code> as their first argument and must be casted in implicit form, <i>i.e.</i> $f(x) \leq 0$.
<code>nlgList</code>	A list object containing the gradient functions as its elements. The functions have to be specified with <code>x</code> as their first argument.
<code>nlhList</code>	A list object containing the Hessian functions as its elements. The functions have to be specified with <code>x</code> as their first argument.
<code>A</code>	An object of class <code>matrix</code> with dimension $p \times n$ or <code>NULL</code> for problems without equality constraints.
<code>b</code>	An object of class <code>vector</code> with dimension $p \times 1$ or <code>NULL</code> for problems without equality constraints.

Value

An object belonging to the reference-class DCP.

 dlp

Creating a member object of the reference-class DLP

Description

This function returns an object containing the definition of a cone constrained linear program. The returned object is a member of the reference-class DLP.

Usage

```
dlp(q, A = NULL, b = NULL, cList = list())
```

Arguments

q	An object of class vector with dimension $n \times 1$.
A	An object of class matrix with dimension $p \times n$ or NULL for problems without equality constraints.
b	An object of class vector with dimension $p \times 1$ or NULL for problems without equality constraints.
cList	A list object containing the cone constraints. Elements must be of either reference-class NNOC, or SOCC, or PSDC or an empty list in case of no inequality constraints.

Value

An object belonging to the reference-class DLP.

 dn1

Creating a member object of the reference-class DNL

Description

This function returns an object containing the definition of a linear program with non-linear constraints and (if provided) cone constraints. The returned object is a member of the reference-class DNL.

Usage

```
dn1(q, A = NULL, b = NULL, cList = list(),
    x0, nlfList = list(), nlgList = list(), nlhList = list())
```

Arguments

q	vector of length n for the coefficients in the objective.
A	An object of class <code>matrix</code> with dimension $p \times n$ or NULL for problems without equality constraints.
b	An object of class <code>vector</code> with dimension $p \times 1$ or NULL for problems without equality constraints.
cList	A list object containing the cone constraints. Elements must be of either S4-class NNOC, or SOCC, or PSDC or an empty list in case of no inequality constraints.
x0	An object of class <code>vector</code> with dimension $n \times 1$ for the initial values. The point x0 must be in the domain of the nonlinear constraints.
nlfList	A list object containing the nonlinear constraints as its elements. The functions have to be specified with x as their first argument and must be casted in implicit form, <i>i.e.</i> $f(x) \leq 0$.
nlgList	A list object containing the gradient functions as its elements. The functions have to be specified with x as their first argument.
nlhList	A list object containing the Hessian functions as its elements. The functions have to be specified with x as their first argument.

Value

An object belonging to the reference-class DNL.

dqp

Creating a member object of the reference-class DQP

Description

This function returns an object containing the definition of a cone constrained quadratic program. The returned object is a member of the reference-class DQP.

Usage

```
dqp(P, q, A = NULL, b = NULL, cList = list())
```

Arguments

P	An object of class <code>matrix</code> with dimension $n \times n$.
q	An object of class <code>vector</code> with dimension $n \times 1$.
A	An object of class <code>matrix</code> with dimension $p \times n$ or NULL for problems without equality constraints.
b	An object of class <code>vector</code> with dimension $p \times 1$ or NULL for problems without equality constraints.
cList	A list object containing the cone constraints. Elements must be of either reference-class NNOC, or SOCC, or PSDC or an empty list in case of no inequality constraints.

Value

An object belonging to the reference-class DQP.

getFoo	<i>Extractor methods for reference class objects</i>
--------	--

Description

Returns a member of reference class objects.

Usage

```
## S4 method for signature 'Rcpp_PDV'  
getx(object)  
## S4 method for signature 'Rcpp_CPS'  
getx(object)  
## S4 method for signature 'Rcpp_PDV'  
gety(object)  
## S4 method for signature 'Rcpp_CPS'  
gety(object)  
## S4 method for signature 'Rcpp_PDV'  
gets(object)  
## S4 method for signature 'Rcpp_CPS'  
gets(object)  
## S4 method for signature 'Rcpp_PDV'  
getz(object)  
## S4 method for signature 'Rcpp_CPS'  
getz(object)  
## S4 method for signature 'Rcpp_CPS'  
getstate(object)  
## S4 method for signature 'Rcpp_CPS'  
getstatus(object)  
## S4 method for signature 'Rcpp_CPS'  
getniter(object)  
## S4 method for signature 'Rcpp_CTRL'  
getparams(object)
```

Arguments

object An object of either reference-class Rcpp_PDV or Rcpp_CPS, or Rcpp_CTRL.

Value

The relevant member object of the class.

gp

Geometric program

Description

This function solves a geometric program.

Usage

```
gp(F0, g0, FList = list(), gList = list(), nno = NULL,  
  A = NULL, b = NULL, optctrl = ctrl())
```

Arguments

F0	Matrix in the objective function.
g0	Matrix in the objective function (affine terms).
FList	List of matrices in posinomial functions.
gList	List of matrices in posinomial functions (affine terms).
nno	Object created by a call to <code>nnoc()</code> .
A	Lefthand-side matrix of equality constraints.
b	Lefthand-side matrix of equality constraints.
optctrl	Object of reference class ‘Rcpp_CTRL’, created by a call to <code>ctrl()</code> .

Details

Solves a geometric program casted in its epigraph form.

Value

An object of S4-class `Rcpp_CPS`.

References

Boyd, S., Kim, S.-J., Vandenberghe, L. and A. Hassibi (2007), A tutorial on geometric programming, *Optim Eng*, Educational Section, **8**:67–127, Springer.

 11 *Minimizing L1-norm*

Description

This function minimizes a L1-norm of the form $\|Pu - q\|_1$, whereby P is a $(m \times n)$ matrix and q is a $m \times 1$ vector. This function is wrapper function for invoking the cps-method of Linear Programs.

Usage

```
l1(P, q = NULL, optctrl = ctrl())
```

Arguments

P	matrix of dimension $m \times n$.
q	vector of length m .
optctrl	An object of S4-class Rcpp_CTRL.

Value

An object of S4-class Rcpp_CPS.

 nlfcr *Definition of nonlinear inequality constraints*

Description

This function is the interface to the reference class NLFC for creating nonlinear constraints.

Usage

```
nlfcr(G, h)
```

Arguments

G	Object of class "matrix": A $(m \times n)$ matrix containing the coefficients of the lefthand-side linear inequality constraints.
h	Object of class NLFC: A $(m \times 1)$ vector containing the coefficients of the righthand-side linear inequality constraints as slot u.

Value

List with elements: conType, G and h.

 nnoc

Definition of linear inequality constraints

Description

This function is the interface to the reference class NNOC for creating linear constraints.

Usage

nnoc(G, h)

Arguments

G	Object of class "matrix": A $(m \times n)$ matrix containing the coefficients of the lefthand-side linear inequality constraints.
h	Object of class NNOC: A $(m \times 1)$ vector containing the coefficients of the righthand-side linear inequality constraints as slot u.

Value

List with elements: conType, G and h.

psdc

Definition of positive semidefinite cone inequality constraints

Description

This function is the interface to the reference class PSDC for creating positive semidefinite cone constraints.

Usage

psdc(Flist, F0)

Arguments

Flist	Object of class "list": A list with the matrices appearing on the left-hand side of the matrix inequality.
F0	Object of class "matrix": The matrix appearing on the righthand-side.

Details

A psd-cone constraint is given as $\sum_{i=1}^n x_i F_i \leq F_0$. The matrix G is created as $G = [\text{vech}(F_1) | \dots | \text{vech}(F_n)]$ and the vector h is constructed as $h = [\text{vech}(F_0)]$.

Value

List with elements: conType, G and h.

Rcpp_CONEC-class	Class "Rcpp_CONEC"
------------------	--------------------

Description

Class for inequality (cone) constraints.

Extends

Class "[C++Object](#)", directly. All reference classes extend and inherit methods from "[envRefClass](#)".

Fields

cone: Object of class `activeBindingFunction`: Type of cone constraints.

G: Object of class `activeBindingFunction`: Left-hand side of inequality constraints.

h: Object of class `activeBindingFunction`: Right-hand side of inequality constraints.

sidx: Object of class `activeBindingFunction`: Row index for subsets of cone constraints.

dims: Object of class `activeBindingFunction`: Dimension of cone constraints.

K: Object of class `activeBindingFunction`: Count of inequality constraints.

n: Object of class `activeBindingFunction`: Count of variables in objective.

Examples

```
showClass("Rcpp_CONEC")
```

Rcpp_CPS-class	Class "Rcpp_CPS"
----------------	------------------

Description

Class for solution of convex programs.

Extends

Class "[C++Object](#)", directly. All reference classes extend and inherit methods from "[envRefClass](#)".

Fields

pdv: Object of class `activeBindingFunction`: Primal-dual variables.

state: Object of class `activeBindingFunction`: Vector of state variables in convex programs.

status: Object of class `activeBindingFunction`: Character indicating the status of the returned solution.

niter: Object of class `activeBindingFunction`: Integer, count of iterations.

sidx: Object of class `activeBindingFunction`: Integer matrix, start and end indices of slack variables.

Examples

```
showClass("Rcpp_CPS")
```

Rcpp_CTRL-class	Class "Rcpp_CTRL"
-----------------	-------------------

Description

Class for control options used in optimization routines.

Extends

Class "[C++Object](#)", directly. All reference classes extend and inherit methods from "[envRefClass](#)".

Fields

ctrlparams: Object of class `activeBindingFunction`: List of control parameters.

Examples

```
showClass("Rcpp_CTRL")
```

Rcpp_DCP-class	Class "Rcpp_DCP"
----------------	------------------

Description

Class for definition of convex programs with non-linear constraints.

Extends

Class "[C++Object](#)", directly. All reference classes extend and inherit methods from "[envRefClass](#)".

Fields

x0: Object of class `activeBindingFunction`: Initial values.

cList: Object of class `activeBindingFunction`: Inequality constraints, class `CONEC`.

nList: Object of class `activeBindingFunction`: List with elements of functions for evaluating non-linear constraints, their associated gradients and their associated Hessians.

A: Object of class `activeBindingFunction`: Left-hand side of equality constraints.

b: Object of class `activeBindingFunction`: Right-hand side of equality constraints.

Examples

```
showClass("Rcpp_DCP")
```

Rcpp_DLP-class	Class "Rcpp_DLP"
----------------	------------------

Description

Class for definition of linear programs.

Extends

Class "[C++Object](#)", directly. All reference classes extend and inherit methods from "[envRefClass](#)".

Fields

q: Object of class `activeBindingFunction`: Matrix related to linear term in objective.
A: Object of class `activeBindingFunction`: Left-hand side of equality constraints.
b: Object of class `activeBindingFunction`: Right-hand side of equality constraints.
cList: Object of class `activeBindingFunction`: Inequality constraints, class `CONEC`.

Examples

```
showClass("Rcpp_DLP")
```

Rcpp_DNL-class	Class "Rcpp_DNL"
----------------	------------------

Description

Class for definition of linear programs with non-linear constraints.

Extends

Class "[C++Object](#)", directly. All reference classes extend and inherit methods from "[envRefClass](#)".

Fields

q: Object of class `activeBindingFunction`: Matrix related to linear term in objective.
A: Object of class `activeBindingFunction`: Left-hand side of equality constraints.
b: Object of class `activeBindingFunction`: Right-hand side of equality constraints.
cList: Object of class `activeBindingFunction`: Inequality constraints, class `CONEC`.
x0: Object of class `activeBindingFunction`: Initial values.
nList: Object of class `activeBindingFunction`: List with elements of functions for evaluating non-linear constraints, their associated gradients and their associated Hessians.

Examples

```
showClass("Rcpp_DNL")
```

Rcpp_DQP-class	Class "Rcpp_DQP"
----------------	------------------

Description

Class for definition of quadratic programs.

Extends

Class "[C++Object](#)", directly. All reference classes extend and inherit methods from "[envRefClass](#)".

Fields

P: Object of class `activeBindingFunction`: Matrix related to quadratic term in objective.
q: Object of class `activeBindingFunction`: Matrix related to linear term in objective.
A: Object of class `activeBindingFunction`: Left-hand side of equality constraints.
b: Object of class `activeBindingFunction`: Right-hand side of equality constraints.
cList: Object of class `activeBindingFunction`: Inequality constraints, class `CONEC`.

Examples

```
showClass("Rcpp_DQP")
```

Rcpp_PDV-class	Class "Rcpp_PDV"
----------------	------------------

Description

Class for primal/dual variables in convex programs.

Extends

Class "[C++Object](#)", directly. All reference classes extend and inherit methods from "[envRefClass](#)".

Fields

x: Object of class `activeBindingFunction`: Primal variables.
y: Object of class `activeBindingFunction`: Dual variables.
s: Object of class `activeBindingFunction`: Primal slack variables.
z: Object of class `activeBindingFunction`: Dual slack variables.
kappa: Object of class `activeBindingFunction`: Self-dual embedding variable; used in LPs, only.
tau: Object of class `activeBindingFunction`: Self-dual embedding variable; used in LPs, only.

Examples

```
showClass("Rcpp_PDV")
```

rp	<i>Risk-parity optimization</i>
----	---------------------------------

Description

This function determines a risk-parity solution of a long-only portfolio with a budget-constraint.

Usage

```
rp(x0, P, mrc, optctrl = ctrl())
```

Arguments

x0	matrix of dimension $n \times 1$; starting values.
P	matrix of dimension $n \times n$; dispersion matrix.
mrc	matrix of dimension $n \times 1$; the marginal risk contributions.
optctrl	An object of S4-class Rcpp_CTRL.

Value

An object of S4-class Rcpp_CPS.

References

Spinu, F. (2013), An Algorithm for Computing Risk Parity Weights, SSRN, *OMERS Capital Markets*, July 2013.

socc	<i>Definition of second-order cone inequality constraints</i>
------	---

Description

This function is the interface to the reference class SOCC for creating second-order cone constraints.

Usage

```
socc(F, g, d, f)
```

Arguments

F	Object of class "matrix": The matrix appearing in the norm-expression on the left-hand side of a second-order cone constraint.
g	Object of class "numeric": The vector appearing in the norm-expression on the left-hand side of a second-order cone constraint.
d	Object of class "numeric": The vector appearing on the right-hand side of a second-order cone constraint.
f	Object of class "numeric": The scalar appearing on the right-hand side of a second-order cone constraint.

Details

A second-order cone constraint is given as $\|Fx + g\|_2 \leq d'x + f$. The matrix G is created as $G = [-d, -F]$ and the vector h is constructed as $h = [f, g]$.

Value

List with elements: conType, G and h.

Index

* classes

- CPD-class, 3
- nlf, 11
- nnoc, 12
- psdc, 12
- Rcpp_CONEC-class, 13
- Rcpp_CPS-class, 13
- Rcpp_CTRL-class, 14
- Rcpp_DCP-class, 14
- Rcpp_DLP-class, 15
- Rcpp_DNL-class, 15
- Rcpp_DQP-class, 16
- Rcpp_PDV-class, 16
- socc, 17

* datasets

- CPG, 3

* optimize

- cccp, 2
- cps, 4
- ctrl, 5
- dcp, 6
- dlp, 7
- dn1, 7
- dqp, 8
- getFoo, 9
- gp, 10
- l1, 11
- rp, 17

C++Object, 13–16

- cccp, 2
- CONEC (CPG), 3
- CPD-class, 3
- CPG, 3
- CPS (CPG), 3
- cps, 4
- cps, Rcpp_DCP, Rcpp_CTRL-method (cps), 4
- cps, Rcpp_DLP, Rcpp_CTRL-method (cps), 4
- cps, Rcpp_DNL, Rcpp_CTRL-method (cps), 4
- cps, Rcpp_DQP, Rcpp_CTRL-method (cps), 4

CTRL (CPG), 3

ctrl, 5

DCP (CPG), 3

dcp, 6

DLP (CPG), 3

dlp, 7

DNL (CPG), 3

dn1, 7

DQP (CPG), 3

dqp, 8

envRefClass, 13–16

getFoo, 9

getniter (getFoo), 9

getniter, Rcpp_CPS-method (getFoo), 9

getparams (getFoo), 9

getparams, Rcpp_CTRL-method (getFoo), 9

gets (getFoo), 9

gets, Rcpp_CPS-method (getFoo), 9

gets, Rcpp_PDV-method (getFoo), 9

getState (getFoo), 9

getState, Rcpp_CPS-method (getFoo), 9

getStatus (getFoo), 9

getStatus, Rcpp_CPS-method (getFoo), 9

getX (getFoo), 9

getX, Rcpp_CPS-method (getFoo), 9

getX, Rcpp_PDV-method (getFoo), 9

getY (getFoo), 9

getY, Rcpp_CPS-method (getFoo), 9

getY, Rcpp_PDV-method (getFoo), 9

getz (getFoo), 9

getz, Rcpp_CPS-method (getFoo), 9

getz, Rcpp_PDV-method (getFoo), 9

gp, 10

gpp (CPG), 3

l1, 11

nlf, 11

nnoc, [12](#)

PDV (CPG), [3](#)

psdc, [12](#)

Rcpp_CONEC-class, [13](#)

Rcpp_CPS-class, [13](#)

Rcpp_CTRL, [5](#)

Rcpp_CTRL-class, [14](#)

Rcpp_DCP-class, [14](#)

Rcpp_DLP-class, [15](#)

Rcpp_DNL-class, [15](#)

Rcpp_DQP-class, [16](#)

Rcpp_PDV-class, [16](#)

rp, [17](#)

rpp (CPG), [3](#)

socc, [17](#)