

Package ‘clarabel’

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Type Package

Title Interior Point Conic Optimization Solver

Version 0.11.3

Description

A versatile interior point solver that solves linear programs (LPs), quadratic programs (QPs), second-order cone programs (SOCPs), semidefinite programs (SDPs), and problems with exponential and power cone constraints (<https://clarabel.org/stable/>). For quadratic objectives, unlike interior point solvers based on the standard homogeneous self-dual embedding (HSDE) model, Clarabel handles quadratic objective without requiring any epigraphical reformulation of its objective function. It can therefore be significantly faster than other HSDE-based solvers for problems with quadratic objective functions. Infeasible problems are detected using a homogeneous embedding technique.

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Encoding UTF-8

URL <https://oxfordcontrol.github.io/clarabel-r/>

BugReports <https://github.com/oxfordcontrol/clarabel-r/issues>

Suggests knitr, Matrix, rmarkdown, tinytest

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and GNU Make

Imports cli, methods

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clarabel	<i>Interface to 'Clarabel', an interior point conic solver</i>
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Description

Clarabel solves linear programs (LPs), quadratic programs (QPs), second-order cone programs (SOCPs) and semidefinite programs (SDPs). It also solves problems with exponential and power cone constraints. The specific problem solved is:

Minimize

$$\frac{1}{2}x^T Px + q^T x$$

subject to

$$Ax + s = b$$

$$s \in K$$

where $x \in R^n$, $s \in R^m$, $P = P^T$ and nonnegative-definite, $q \in R^n$, $A \in R^{m \times n}$, and $b \in R^m$. The set K is a composition of convex cones.

Usage

```
clarabel(A, b, q, P = NULL, cones, control = list(), strict_cone_order = TRUE)
```

Arguments

A	a matrix of constraint coefficients.
b	a numeric vector giving the primal constraints
q	a numeric vector giving the primal objective
P	a symmetric positive semidefinite matrix, default NULL

cones	a named list giving the cone sizes, see “Cone Parameters” below for specification
control	a list giving specific control parameters to use in place of default values, with an empty list indicating the default control parameters. Specified parameters should be correctly named and typed to avoid Rust system panics as no sanitization is done for efficiency reasons
strict_cone_order	a logical flag, default TRUE for forcing order of cones described below. If FALSE cones can be specified in any order and even repeated and directly passed to the solver without type and length checks

Details

The order of the rows in matrix A has to correspond to the order given in the table “Cone Parameters”, which means means rows corresponding to *primal zero cones* should be first, rows corresponding to *non-negative cones* second, rows corresponding to *second-order cone* third, rows corresponding to *positive semidefinite cones* fourth, rows corresponding to *exponential cones* fifth and rows corresponding to *power cones* at last.

When the parameter `strict_cone_order` is FALSE, one can specify the cones in any order and even repeat them in the order they appear in the A matrix. See below.

Clarabel can solve:

1. linear programs (LPs)
2. second-order cone programs (SOCPs)
3. exponential cone programs (ECPs)
4. power cone programs (PCPs)
5. problems with any combination of cones, defined by the parameters listed in “Cone Parameters” below

Cone Parameters: The table below shows the cone parameter specifications. Mathematical definitions are in the vignette.

Parameter	Type	Length	Description
z	integer	1	number of primal zero cones (dual free cones), which corresponds to the primal equality constraints
l	integer	1	number of linear cones (non-negative cones)
q	integer	≥ 1	vector of second-order cone sizes
s	integer	≥ 1	vector of positive semidefinite cone sizes
ep	integer	1	number of primal exponential cones
p	numeric	≥ 1	vector of primal power cone parameters
gp	list	≥ 1	list of named lists of two items, a : a numeric vector of at least 2 exponent terms in the p

When the parameter `strict_cone_order` is FALSE, one can specify the cones in the order they appear in the A matrix. The cones argument in such a case should be a named list with names matching z* indicating primal zero cones, l* indicating linear cones, and so on. For example, either of the following would be valid: `list(z = 2L, l = 2L, q = 2L, z = 3L, q = 3L)`, or `list(z1 = 2L, l1 = 2L, q1 = 2L, z2 = 3L, q2 = 3L)`, indicating a zero cone of size 2, followed by a linear

cone of size 2, followed by a second-order cone of size 2, followed by a zero cone of size 3, and finally a second-order cone of size 3. Generalized power cones parameters have to be specified as named lists, e.g., `list(z = 2L, gp1 = list(a = c(0.3, 0.7), n = 3L), gp2 = list(a = c(0.5, 0.5), n = 1L))`.

Note that when `strict_cone_order = FALSE`, types of cone parameters such as integers, reals have to be explicit since the parameters are directly passed to the Rust interface with no sanity checks!

Value

named list of solution vectors `x`, `y`, `s` and information about run

See Also

`clarabel_control()`

Examples

```
A <- matrix(c(1, 1), ncol = 1)
b <- c(1, 1)
obj <- 1
cone <- list(z = 2L)
control <- clarabel_control(tol_gap_rel = 1e-7, tol_gap_abs = 1e-7, max_iter = 100)
clarabel(A = A, b = b, q = obj, cones = cone, control = control)
```

ClarabelSolver

A persistent Clarabel solver that can be reused across R calls.

Description

A persistent Clarabel solver that can be reused across R calls.

Usage

ClarabelSolver

clarabel_control

Control parameters with default values and types in parenthesis

Description

Control parameters with default values and types in parenthesis

Usage

```

clarabel_control(
  max_iter = 200L,
  time_limit = Inf,
  verbose = TRUE,
  max_step_fraction = 0.99,
  tol_gap_abs = 1e-08,
  tol_gap_rel = 1e-08,
  tol_feas = 1e-08,
  tol_infeas_abs = 1e-08,
  tol_infeas_rel = 1e-08,
  tol_ktratio = 1e-06,
  reduced_tol_gap_abs = 5e-05,
  reduced_tol_gap_rel = 5e-05,
  reduced_tol_feas = 1e-04,
  reduced_tol_infeas_abs = 5e-12,
  reduced_tol_infeas_rel = 5e-05,
  reduced_tol_ktratio = 1e-04,
  equilibrate_enable = TRUE,
  equilibrate_max_iter = 10L,
  equilibrate_min_scaling = 1e-04,
  equilibrate_max_scaling = 10000,
  linesearch_backtrack_step = 0.8,
  min_switch_step_length = 0.1,
  min_terminate_step_length = 1e-04,
  max_threads = 0L,
  direct_kkt_solver = TRUE,
  direct_solve_method = c("auto", "qdl1l"),
  static_regularization_enable = TRUE,
  static_regularization_constant = 1e-08,
  static_regularization_proportional = .Machine$double.eps * .Machine$double.eps,
  dynamic_regularization_enable = TRUE,
  dynamic_regularization_eps = 1e-13,
  dynamic_regularization_delta = 2e-07,
  iterative_refinement_enable = TRUE,
  iterative_refinement_reltol = 1e-13,
  iterative_refinement_abstol = 1e-12,
  iterative_refinement_max_iter = 10L,
  iterative_refinement_stop_ratio = 5,
  presolve_enable = TRUE,
  input_sparse_dropzeros = FALSE,
  chordal_decomposition_enable = TRUE,
  chordal_decomposition_merge_method = c("clique_graph", "parent_child", "none"),
  chordal_decomposition_compact = TRUE,
  chordal_decomposition_complete_dual = TRUE
)

```

Arguments

max_iter	maximum number of iterations (200L)
time_limit	maximum run time (seconds) (Inf)
verbose	verbose printing (TRUE)
max_step_fraction	maximum interior point step length (0.99)
tol_gap_abs	absolute duality gap tolerance (1e-8)
tol_gap_rel	relative duality gap tolerance (1e-8)
tol_feas	feasibility check tolerance (primal and dual) (1e-8)
tol_infeas_abs	absolute infeasibility tolerance (primal and dual) (1e-8)
tol_infeas_rel	relative infeasibility tolerance (primal and dual) (1e-8)
tol_ktratio	KT tolerance (1e-6)
reduced_tol_gap_abs	reduced absolute duality gap tolerance (5e-5)
reduced_tol_gap_rel	reduced relative duality gap tolerance (5e-5)
reduced_tol_feas	reduced feasibility check tolerance (primal and dual) (1e-4)
reduced_tol_infeas_abs	reduced absolute infeasibility tolerance (primal and dual) (5e-12)
reduced_tol_infeas_rel	reduced relative infeasibility tolerance (primal and dual) (5e-5)
reduced_tol_ktratio	reduced KT tolerance (1e-4)
equilibrate_enable	enable data equilibration pre-scaling (TRUE)
equilibrate_max_iter	maximum equilibration scaling iterations (10L)
equilibrate_min_scaling	minimum equilibration scaling allowed (1e-4)
equilibrate_max_scaling	maximum equilibration scaling allowed (1e+4)
linesearch_backtrack_step	linesearch backtracking (0.8)
min_switch_step_length	minimum step size allowed for asymmetric cones with PrimalDual scaling (1e-1)
min_terminate_step_length	minimum step size allowed for symmetric cones && asymmetric cones with Dual scaling (1e-4)
max_threads	maximum solver threads for multithreaded KKT solvers, 0 lets the solver choose for itself (0L)
direct_kkt_solver	use a direct linear solver method (required true) (TRUE)

```

direct_solve_method
    direct linear solver, either "auto" or "qdlldl" ("auto"). This build links only
    the QDLDL solver, so "auto" resolves to "qdlldl"; the two are equivalent here.
static_regularization_enable
    enable KKT static regularization (TRUE)
static_regularization_constant
    KKT static regularization parameter (1e-8)
static_regularization_proportional
    additional regularization parameter w.r.t. the maximum abs diagonal term ( $\text{.Machine.double\_eps}^2$ )
dynamic_regularization_enable
    enable KKT dynamic regularization (TRUE)
dynamic_regularization_eps
    KKT dynamic regularization threshold (1e-13)
dynamic_regularization_delta
    KKT dynamic regularization shift (2e-7)
iterative_refinement_enable
    KKT solve with iterative refinement (TRUE)
iterative_refinement_reltol
    iterative refinement relative tolerance (1e-13)
iterative_refinement_abstol
    iterative refinement absolute tolerance (1e-12)
iterative_refinement_max_iter
    iterative refinement maximum iterations (10L)
iterative_refinement_stop_ratio
    iterative refinement stalling tolerance (5.0)
presolve_enable
    whether to enable presolve (TRUE)
input_sparse_dropzeros
    explicitly drop structural zeros from sparse data inputs (FALSE); see details
chordal_decomposition_enable
    whether to enable chordal decomposition for SDPs (TRUE)
chordal_decomposition_merge_method
    chordal decomposition merge method, one of 'clique_graph', 'parent_child'
    or 'none', for SDPs ('clique_graph')
chordal_decomposition_compact
    a boolean flag for SDPs indicating whether to assemble decomposed system in
    compact form for SDPs (TRUE)
chordal_decomposition_complete_dual
    a boolean flag indicating complete PSD dual variables after decomposition for
    SDPs (TRUE)

```

Details

Setting `input_sparse_dropzeros` to `TRUE` will disable parametric updating functionality. See documentation of 'dropzeros' in Rust struct `CscMatrix` for dropping structural zeros before passing to the solver.

These defaults track the Rust solver (Clarabel.rs 0.11.1) exactly. The only departure is the set of values accepted for `direct_solve_method`, which is limited by the features this package is built with.

Chordal decomposition applies only to semidefinite programs, and only when the aggregate sparsity pattern of the semidefinite constraints is decomposable. For such problems it can be dramatically faster, since it replaces one large semidefinite cone by several small ones. It has two consequences worth knowing. The reported dual variables for semidefinite constraints are not in general the same as those obtained without decomposition, because the decomposition is reversed and the dual completed, and a positive semidefinite completion is not unique. It also blocks the data updates used for warm starts, but only when a decomposition actually took place: linear, quadratic and second-order cone problems are unaffected, and remain updatable. See [solver_is_update_allowed\(\)](#) to check a particular solver instance.

Value

a list containing the control parameters.

Examples

```
# Default control parameters
ctrl <- clarabel_control()
ctrl$max_iter
# Custom tolerances and quiet output
ctrl <- clarabel_control(verbose = FALSE, tol_gap_rel = 1e-7, max_iter = 100L)
```

clarabel_solver	<i>Create a persistent Clarabel solver object</i>
-----------------	---

Description

Creates a persistent solver that can be reused across multiple solves with updated problem data (warm starts). This avoids the overhead of reallocating the solver's internal data structures when only the problem data changes but the sparsity pattern stays the same.

Usage

```
clarabel_solver(
  A,
  b,
  q,
  P = NULL,
  cones,
  control = list(),
  strict_cone_order = TRUE
)
```

Arguments

A	a matrix of constraint coefficients.
b	a numeric vector giving the primal constraints
q	a numeric vector giving the primal objective
P	a symmetric positive semidefinite matrix, default NULL
cones	a named list giving the cone sizes, see “Cone Parameters” below for specification
control	a list giving specific control parameters to use in place of default values, with an empty list indicating the default control parameters. Specified parameters should be correctly named and typed to avoid Rust system panics as no sanitization is done for efficiency reasons
strict_cone_order	a logical flag, default TRUE for forcing order of cones described below. If FALSE cones can be specified in any order and even repeated and directly passed to the solver without type and length checks

Details

Data updates are refused once the solver has altered the structure of the problem, since the stored factorization no longer corresponds to the data being updated. Three settings can cause that: `presolve_enable`, `input_sparse_dropzeros` and `chordal_decomposition_enable`. What matters is whether the transformation actually took place, not whether it was permitted: `presolve` rewrites the problem only if it finds something to remove, and chordal decomposition engages only for semidefinite constraints whose sparsity pattern is decomposable. Use [`solver\_is\_update\_allowed\(\)`](#) to check the instance you built.

Value

a `ClarabelSolver` environment object with methods `solve()`, `update_data(Px, Ax, q, b)`, and `is_update_allowed()`

See Also

[`solver\_solve\(\)`](#), [`solver\_update\(\)`](#), [`solver\_is\_update\_allowed\(\)`](#), [`clarabel\(\)`](#)

Examples

```
## Not run:
P <- Matrix::sparseMatrix(i = 1:2, j = 1:2, x = c(2, 1), dims = c(2, 2))
A <- matrix(c(1, 0, 0, 1), nrow = 2)
b <- c(1, 1)
q <- c(-2, -3)
cones <- list(l = 2L)
ctrl <- clarabel_control(presolve_enable = FALSE, verbose = FALSE)
s <- clarabel_solver(A, b, q, P, cones, control = ctrl)
sol1 <- solver_solve(s)
solver_update(s, q = c(-4, -1))
sol2 <- solver_solve(s)
```

```
## End(Not run)
```

```
solver_is_update_allowed
```

Check if data updates are allowed on a persistent solver

Description

Returns FALSE if presolve, chordal decomposition or input_sparse_dropzeros has actually restructured this problem, which prevents data updates. Enabling one of those settings is not by itself enough to prevent updates; the transformation has to have taken place.

Usage

```
solver_is_update_allowed(solver)
```

Arguments

`solver` a `ClarabelSolver` object created by `clarabel_solver()`

Value

logical scalar

See Also

`clarabel_solver()`, `solver_update()`

Examples

```
## Not run:
solver_is_update_allowed(s) # FALSE if the problem was restructured

## End(Not run)
```

solver_solve	<i>Solve using a persistent Clarabel solver</i>
--------------	---

Description

Solve using a persistent Clarabel solver

Usage

```
solver_solve(solver)
```

Arguments

solver a ClarabelSolver object created by `clarabel_solver()`

Value

the same named list as `clarabel()`: solution vectors x, z, s and solver information

See Also

`clarabel_solver()`, `solver_update()`

Examples

```
## Not run:
s <- clarabel_solver(A, b, q, P, cones,
                    control = clarabel_control(presolve_enable = FALSE,
                                              verbose = FALSE))

sol <- solver_solve(s)
sol$status

## End(Not run)
```

solver_status_descriptions	<i>Return the solver status description as a named character vector</i>
----------------------------	---

Description

Return the solver status description as a named character vector

Usage

```
solver_status_descriptions()
```

Value

a named list of solver status descriptions, in order of status codes returned by the solver

Examples

```
solver_status_descriptions()[2] ## for solved problem
solver_status_descriptions()[8] ## for max iterations limit reached
```

solver_update	<i>Update problem data on a persistent Clarabel solver</i>
---------------	--

Description

Update one or more of P (objective), q (linear objective), A (constraints), b (constraint RHS) on an existing solver. The sparsity pattern of P and A must remain the same as the original problem; only the nonzero values can change.

Usage

```
solver_update(solver, P = NULL, q = NULL, A = NULL, b = NULL)
```

Arguments

solver	a ClarabelSolver object created by clarabel_solver()
P	new upper-triangular P matrix (same sparsity), or NULL to leave unchanged
q	new linear objective vector, or NULL to leave unchanged
A	new constraint matrix (same sparsity), or NULL to leave unchanged
b	new constraint RHS vector, or NULL to leave unchanged

Value

invisible NULL

See Also

[clarabel_solver\(\)](#), [solver_solve\(\)](#)

Examples

```
## Not run:
solver_update(s, q = c(-4, -1)) # update linear objective only
solver_update(s, b = c(2, 2))  # update constraint RHS only
sol2 <- solver_solve(s)        # re-solve with updated data

## End(Not run)
```

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