

The lpSolve Package

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Title Interface to Lp_solve v. 5.5 to solve linear/integer programs

Author Michel Berkelaar and others

Maintainer Sam Buttrely <buttrely@nps.edu>

Description Lp_solve is freely available (under LGPL 2) software for solving linear, integer and mixed integer programs. In this implementation we supply a “wrapper” function in C and some R functions that solve general linear/integer problems, assignment problems, and transportation problems. This version calls lp_solve version 5.5.

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lp *Linear and Integer Programming*

Description

Interface to lp_solve linear/integer programming system

Usage

```
lp (direction = "min", objective.in, const.mat, const.dir, const.rhs,
    transpose.constraints = TRUE, int.vec, presolve=0, compute.sens=0,
    binary.vec, all.int=FALSE, all.bin=FALSE, scale = 196, dense.const,
    num.bin.solns=1, use.rw=FALSE)
```

Arguments

<code>direction</code>	Character string giving direction of optimization: "min" (default) or "max."
<code>objective.in</code>	Numeric vector of coefficients of objective function
<code>const.mat</code>	Matrix of numeric constraint coefficients, one row per constraint, one column per variable (unless <code>transpose.constraints = FALSE</code> ; see below).
<code>const.dir</code>	Vector of character strings giving the direction of the constraint: each value should be one of "<," "<=," "=", "==," ">," or ">=". (In each pair the two values are identical.)
<code>const.rhs</code>	Vector of numeric values for the right-hand sides of the constraints.
<code>transpose.constraints</code>	By default each constraint occupies a row of <code>const.mat</code> , and that matrix needs to be transposed before being passed to the optimizing code. For very large constraint matrices it may be wiser to construct the constraints in a matrix column-by-column. In that case set <code>transpose.constraints</code> to <code>FALSE</code> .
<code>int.vec</code>	Numeric vector giving the indices of variables that are required to be integer. The length of this vector will therefore be the number of integer variables.
<code>presolve</code>	Numeric: presolve? Default 0 (no); any non-zero value means "yes." Currently ignored.
<code>compute.sens</code>	Numeric: compute sensitivity? Default 0 (no); any non-zero value means "yes."
<code>binary.vec</code>	Numeric vector like <code>int.vec</code> giving the indices of variables that are required to be binary.
<code>all.int</code>	Logical: should all variables be integer? Default: <code>FALSE</code> .
<code>all.bin</code>	Logical: should all variables be binary? Default: <code>FALSE</code> .
<code>scale</code>	Integer: value for lpSolve scaling. Details can be found in the lpSolve documentation. Set to 0 for no scaling. Default: 196
<code>dense.const</code>	Three column dense constraint array. This is ignored if <code>const.mat</code> is supplied. Otherwise the columns are constraint number, column number, and value; there should be one row for each non-zero entry in the constraint matrix.
<code>num.bin.solns</code>	Integer: if <code>all.bin=TRUE</code> , the user can request up to <code>num.bin.solns</code> optimal solutions to be returned.
<code>use.rw</code>	Logical: if <code>TRUE</code> and <code>num.bin.solns > 1</code> , write the lp out to a file and read it back in for each solution after the first. This is just to defeat a bug somewhere. Although the default is <code>FALSE</code> , we recommend you set this to <code>TRUE</code> if you need <code>num.bin.solns > 1</code> , until the bug is found.

Details

This function calls the lp_solve 5.5 solver. That system has many options not supported here. The current version is maintained at ftp://ftp.es.ele.tue.nl/pub/lp_solve

Value

An lp object. See [lp.object](#) for details.

Author(s)

Sam Buttrely, (buttrely@nps.edu)

See Also

[lp.assign](#), [lp.transport](#)

Examples

```
#
# Set up problem: maximize
#   x1 + 9 x2 +   x3 subject to
#   x1 + 2 x2 + 3 x3 <= 9
# 3 x1 + 2 x2 + 2 x3 <= 15
#
f.obj <- c(1, 9, 3)
f.con <- matrix (c(1, 2, 3, 3, 2, 2), nrow=2, byrow=TRUE)
f.dir <- c("<=", "<=")
f.rhs <- c(9, 15)
#
# Now run.
#
lp ("max", f.obj, f.con, f.dir, f.rhs)
## Not run: Success: the objective function is 40.5
lp ("max", f.obj, f.con, f.dir, f.rhs)$solution
## Not run: [1] 0.0 4.5 0.0
#
# Get sensitivities
#
lp ("max", f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$sens.coef.from
## Not run: [1] -1e+30 2e+00 -1e+30
lp ("max", f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$sens.coef.to
## Not run: [1] 4.50e+00 1.00e+30 1.35e+01
#
# Right now the dual values for the constraints and the variables are
# combined, constraints coming first. So in this example...
#
lp ("max", f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$duals
## Not run: [1] 4.5 0.0 -3.5 0.0 -10.5
#
# ...the duals of the constraints are 4.5 and 0, and of the variables,
# -3.5, 0.0, -10.5. Here are the lower and upper limits on these:
#
```

```

lp ("max", f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$duals.from
## Not run: [1] 0e+00 -1e+30 -1e+30 -1e+30 -6e+00
lp ("max", f.obj, f.con, f.dir, f.rhs, compute.sens=TRUE)$duals.to
## Not run: [1] 1.5e+01 1.0e+30 3.0e+00 1.0e+30 3.0e+00
#
# Run again, this time requiring that all three variables be integer
#
lp ("max", f.obj, f.con, f.dir, f.rhs, int.vec=1:3)
## Not run: Success: the objective function is 37
lp ("max", f.obj, f.con, f.dir, f.rhs, int.vec=1:3)$solution
## Not run: [1] 1 4 0
#
# You can get sensitivities in the integer case, but they're harder to
# interpret.
#
lp ("max", f.obj, f.con, f.dir, f.rhs, int.vec=1:3, compute.sens=TRUE)$duals
## Not run: [1] 1 0 0 7 0
#
# Here's an example in which we want more than one solution to a problem
# in which all variables are binary: the 8-queens problem.
#
chess.obj <- rep (1, 64)
q8 <- make.q8 ()
chess.dir <- rep (c("=", "<"), c(16, 26))
chess.rhs <- rep (1, 42)
lp ('max', chess.obj, , chess.dir, chess.rhs, dense.const = q8,
    all.bin=TRUE, num.bin.solns=3)

```

lp.assign

Integer Programming for the Assignment Problem

Description

Interface to lp_solve linear/integer programming system specifically for solving assignment problems

Usage

```
lp.assign (cost.mat, direction = "min", presolve = 0, compute.sens = 0)
```

Arguments

cost.mat	Matrix of costs: the ij-th element is the cost of assigning source i to destination j.
direction	Character vector, length 1, containing either "min" (the default) or "max"
presolve	Numeric: presolve? Default 0 (no); any non-zero value means "yes." Currently ignored.
compute.sens	Numeric: compute sensitivity? Default 0 (no); any non-zero value means "yes." In that case presolving is attempted.

Details

This is a particular integer programming problem. All the decision variables are assumed to be integers; each row has the constraint that its entries must add up to 1 (so that there is one 1 and the remaining entries are 0) and each column has the same constraint. This is assumed to be a minimization problem.

Value

An `lp` object. See documentation for details. The constraints are assumed (each row adds to 1, each column adds to 1, and no others) and are not returned.

Author(s)

Sam Buttrey, (buttrey@nps.edu)

See Also

`lp`, `lp.transport`

Examples

```
assign.costs <- matrix (c(2, 7, 7, 2, 7, 7, 3, 2, 7, 2, 8, 10, 1, 9, 8, 2), 4, 4)
## Not run:
> assign.costs
      [,1] [,2] [,3] [,4]
[1,]    2    7    7    1
[2,]    7    7    2    9
[3,]    7    3    8    8
[4,]    2    2   10    2
## End(Not run)
lp.assign (assign.costs)
## Not run: Success: the objective function is 8
lp.assign (assign.costs)$solution
## Not run:
      [,1] [,2] [,3] [,4]
[1,]    0    0    0    1
[2,]    0    0    1    0
[3,]    0    1    0    0
[4,]    1    0    0    0
## End(Not run)
```

lp.object

LP (linear programming) object

Description

Structure of `lp` object

Value

An lp.object is a list containing the following elements:

direction	Optimization direction, as entered
x.count	Number of variables in objective function
objective	Vector of objective function coefficients, as entered
const.count	Number of constraints entered
constraints	Constraint matrix, as entered (not returned by <code>lp.assign</code> or <code>lp.transport</code>)
int.count	Number of integer variables
int.vec	Vector of integer variables' indices, as entered
objval	Value of objective function at optimum
solution	Vector of optimal coefficients
num.bin.solns	Numeric indicator of number of solutions returned
status	Numeric indicator: 0 = success, 2 = no feasible solution

Author(s)

Sam Buttrey, (buttrey@nps.edu)

See Also

`lp`, `lp.assign`, `lp.transport`

lp.transport *Integer Programming for the Transportation Problem*

Description

Interface to lp_solve linear/integer programming system specifically for solving transportation problems

Usage

```
lp.transport (cost.mat, direction="min", row.signs, row.rhs, col.signs, col.rhs, pr
```

Arguments

cost.mat	Matrix of costs; ij-th element is the cost of transporting one item from source i to destination j.
direction	Character, length 1: "min" or "max"
row.signs	Vector of character strings giving the direction of the row constraints: each value should be one of "<," "<=," "=", "==," ">," or ">=." (In each pair the two values are identical.)

row.rhs	Vector of numeric values for the right-hand sides of the row constraints.
col.signs	Vector of character strings giving the direction of the column constraints: each value should be one of "<," "<=," "=", "==," ">," or ">=."
col.rhs	Vector of numeric values for the right-hand sides of the column constraints.
presolve	Numeric: presolve? Default 0 (no); any non-zero value means "yes." Currently ignored.
compute.sens	Numeric: compute sensitivity? Default 0 (no); any non-zero value means "yes."
integers	Vector of integers whose ith element gives the index of the ith integer variable. Its length will be the number of integer variables. Default: all variables are integer. Set to NULL to have no variables be integer.

Details

This is a particular integer programming problem. All the decision variables are assumed to be integers, and there is one constraint per row and one per column (and no others). This is assumed to be a minimization problem.

Value

An `lp` object. Constraints are implicit and not returned. See documentation for details.

Author(s)

Sam Buttrey, (buttrey@nps.edu)

References

Example problem from Bronson (1981), *Operations Research*, Scahum's Outline Series, McGraw-Hill.

See Also

`lp.assign`, `lp.transport`

Examples

```
#
# Transportation problem, Bronson, problem 9.1, p. 86
#
# Set up cost matrix
#
costs <- matrix (10000, 8, 5); costs[4,1] <- costs[-4,5] <- 0
costs[1,2] <- costs[2,3] <- costs[3,4] <- 7; costs[1,3] <- costs[2,4] <- 7.7
costs[5,1] <- costs[7,3] <- 8; costs[1,4] <- 8.4; costs[6,2] <- 9
costs[8,4] <- 10; costs[4,2:4] <- c(.7, 1.4, 2.1)
#
# Set up constraint signs and right-hand sides.
#
row.signs <- rep("<", 8)
```

```

row.rhs <- c(200, 300, 350, 200, 100, 50, 100, 150)
col.signs <- rep(">", 5)
col.rhs <- c(250, 100, 400, 500, 200)
#
# Run
#
lp.transport (costs, "min", row.signs, row.rhs, col.signs, col.rhs)
## Not run: Success: the objective function is 7790
lp.transport (costs, "min", row.signs, row.rhs, col.signs, col.rhs)$solution
## Not run:
      [,1] [,2] [,3] [,4] [,5]
[1,]    0  100    0  100    0
[2,]    0    0  300    0    0
[3,]    0    0    0  350    0
[4,]  200    0    0    0    0
[5,]   50    0    0    0   50
[6,]    0    0    0    0   50
[7,]    0    0  100    0    0
[8,]    0    0    0   50  100
## End(Not run)

```

make.q8

Generate sparse constraint matrix for 8-queens problem

Description

Generate sparse constraint matrix for 8-queens problem

Usage

```
make.q8 ()
```

Arguments

None.

Details

Sparse constraints come in a three-column matrix or data frame. Each row gives the row number, column number, and value of a particular non-zero entry in the constraint matrix. This function produces the sparse constraint matrix for the 8-queens problem (in which the object is to place eight queens on a chessboard with no two sharing a row, column or diagonal). The resulting sparse representation is 252 x 3, compared to 42 x 64 for the usual representation.

Value

A 252 x 3 numeric matrix. See [lp](#) for the complete example.

Author(s)

Sam Buttrey, <buttrey@nps.edu>

See Also

[lp](#)

`print.lp`

Print an lp object

Description

Print method for lp objects

Usage

```
## S3 method for class 'lp':  
print(x, ...)
```

Arguments

<code>x</code>	List with items named <code>objval</code> and <code>status</code> . Normally this will have been called by lp , lp.assign , or lp.transport .
<code>...</code>	Other arguments, all currently ignored

Details

This function prints the objective function value, together with the word "Success" if the operation is successful, or an indication of the error if not. If multiple solutions have been produced (because this was an all-binary problem and lp was called with `num.bin.solns > 1`) the number of solutions is also displayed.

Value

None

Author(s)

Sam Buttrey, <buttrey@nps.edu>

See Also

[lp](#), [lp.assign](#), [lp.transport](#)

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