

# Package ‘clhs’

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**Type** Package

**Title** Conditioned Latin Hypercube Sampling

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**Description** Conditioned Latin hypercube sampling, as published by Minasny and McBratney (2006) <DOI:10.1016/j.cageo.2005.12.009>. This method proposes to stratify sampling in presence of ancillary data. An extension of this method, which propose to associate a cost to each individual and take it into account during the optimisation process, is also proposed (Roudier et al., 2012, <DOI:10.1201/b12728>).

**Depends** R (>= 2.14.0)

**Imports** utils, methods, grid, ggplot2, sp, raster, reshape2, plyr,  
scales, cluster

**License** GPL (>= 2)

**LazyLoad** yes

**Suggests** knitr, rmarkdown, testthat

**VignetteBuilder** knitr

**RoxygenNote** 6.0.1

**Collate** 'clhs-internal.R' 'clhs-data.frame.R' 'clhs-package.R'  
'clhs-raster.R' 'utils.R' 'clhs.R' 'clhs-sp.R' 'plot.R'  
'similarity.R'

**NeedsCompilation** no

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**Repository** CRAN

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## R topics documented:

clhs-package	2
clhs.data.frame	3
cLHS_result	6
plot.cLHS_result	7
similarity_buffer	8
<b>Index</b>	<b>10</b>

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clhs-package	<i>Conditioned Latin Hypercube Sampling</i>
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### Description

This package implements the conditioned Latin hypercube sampling, as published by Minasny and McBratney (2006) and the DLHS variant method (Minasny and McBratney, 2010). This method proposes to stratify sampling in presence of ancillary data.

### Details

An extension of this method, which propose to associate a cost to each individual and take it into account during the optimisation process, is also proposed (Roudier et al., 2012).

### Author(s)

Pierre Roudier

### References

\* For the initial cLHS method:

Minasny, B. and McBratney, A.B. 2006. A conditioned Latin hypercube method for sampling in the presence of ancillary information. *Computers and Geosciences*, 32:1378-1388.

\*For the DLHS variant method:

Minasny, B. and A. B. McBratney, A.B.. 2010. Conditioned Latin Hypercube Sampling for Calibrating Soil Sensor Data to Soil Properties. In: *Proximal Soil Sensing, Progress in Soil Science*, pages 111-119.

\* For the cost-constrained implementation:

Roudier, P., Beaudette, D.E. and Hewitt, A.E. 2012. A conditioned Latin hypercube sampling algorithm incorporating operational constraints. In: *Digital Soil Assessments and Beyond. Proceedings of the 5th Global Workshop on Digital Soil Mapping, Sydney, Australia*.

\* For the similarity buffer prediction:

Brungard, C. and Johanson, J. 2015. The gate's locked! I can't get to the exact sampling spot... can I sample nearby? *Pedomatron*, 37:8-10.

**See Also**

sample

**Examples**

```
df <- data.frame(
  a = runif(1000),
  b = rnorm(1000),
  c = sample(LETTERS[1:5], size = 1000, replace = TRUE)
)
res <- clhs(df, size = 50, iter = 2000, progress = FALSE)
str(res)
```

clhs.data.frame

*Conditioned Latin Hypercube Sampling***Description**

Implementation of the conditioned Latin hypercube sampling, as published by Minasny and McBratney (2006) and the DLHS variant method (Minasny and McBratney, 2010). These methods propose to stratify sampling in presence of ancillary data. An extension of this method, which propose to associate a cost to each individual and take it into account during the optimisation process, is also proposed (Roudier et al., 2012).

**Usage**

```
## S3 method for class 'data.frame'
clhs(x, size, include = NULL, cost = NULL,
     iter = 10000, temp = 1, tdecrease = 0.95, weights = list(numeric = 1,
     factor = 1, correlation = 1), eta = 1, obj.limit = -Inf,
     length.cycle = 10, simple = TRUE, progress = TRUE, track = NULL)

## S3 method for class 'Raster'
clhs(x, ...)

clhs(x, size, include, cost, iter, temp, tdecrease, weights, eta, obj.limit,
     length.cycle, simple, progress, track)

## S3 method for class 'SpatialPointsDataFrame'
clhs(x, ...)
```

**Arguments**

x                    A data.frame, SpatialPointsDataFrame or Raster object.  
size                  A non-negative integer giving the total number of items to select

include	A numeric vector giving the indices of the rows from <i>x</i> that must be included in the selected items. For the cost-constrained cLHS method, cost of these mandatory samples is set to 0. If NULL (default), all data are randomly chosen according to the classic cLHS method. If include is not NULL, argument size must include the total size of the final sample i.e. the size of mandatory samples given by include plus the size of the randomly chosen samples to pick.
cost	A character giving the name or an integer giving the index of the attribute in <i>x</i> that gives a cost that can be use to constrain the cLHS sampling. If NULL (default), the cost-constrained implementation is not used.
iter	A positive number, giving the number of iterations for the Metropolis-Hastings annealing process. Defaults to 10000.
temp	The initial temperature at which the simulated annealing begins. Defaults to 1.
tdecrease	A number between 0 and 1, giving the rate at which temperature decreases in the simulated annealing process. Defaults to 0.95.
weights	A list a length 3, giving the relative weights for continuous data, categorical data, and correlation between variables. Defaults to <code>list(numeric = 1, factor = 1, correlation = 1)</code> .
eta	Either a number equal 1 to perform a classic cLHS or a constrained cLHS or a matrix to perform a cLHS that samples more on the edge of the distributions (DLHS, see details)
obj.limit	The minimal value at which the optimisation is stopped. Defaults to <code>-Inf</code> .
length.cycle	The duration (number of iterations) of the isothermperature steps. Defaults to 10.
simple	TRUE or FALSE. If set to TRUE, only the indices of the selected samples are returned, as a numeric vector. If set to FALSE, a <code>cLHS_result</code> object is returned (takes more memory but allows to make use of <code>cLHS_results</code> methods such as <code>plot.cLHS_result</code> ).
progress	TRUE or FALSE, displays a progress bar.
track	A character giving the name or an integer giving the index of the attribute in <i>x</i> that gives a cost associated with each individual. However, this method will only track the cost - the sampling process will not be constrained by this attribute. If NULL (default), this option is not used.
...	additional parameters passed to <code>clhs</code>

### Details

For the DLHS method, the original paper defines parameter *b* as the importance of the edge of the distributions. A matrix *eta* (size *N* x *K*, where *N* is the size of the final sample and *K* the number of continuous variables) is defined, to compute the objective function of the algorithm, where each column equal the vector (*b*, 1, ..., 1, *b*) in order to give the edge of the distribution a probability *b* times higher to be sampled. In our function, instead of define the *b* parameter, users can defined their own *eta* matrix so that they can give more complex probabily design of sampling each strata of the distribution instead of just be able to give more importance to both edges of the distribution.

### Value

\* If the `simple` option is set to TRUE (default behaviour): A numeric vector containing the indices of the selected samples is returned

\* If the `simple` option is set to `FALSE`: An object of class `cLHS_result`, with the following elements:

`index_samples` a vector giving the indices of the chosen samples.  
`sampled_data` the sampled data.frame.  
`obj` a vector giving the evolution of the objective function throughout the Metropolis-Hastings iterations.  
`cost` a vector giving the evolution of the cost function throughout the Metropolis-Hastings iterations (if available).

### Author(s)

Pierre Roudier

### References

\*For the initial cLHS method:

Minasny, B. and McBratney, A.B. 2006. A conditioned Latin hypercube method for sampling in the presence of ancillary information. *Computers and Geosciences*, 32:1378-1388.

\*For the DLHS method:

Minasny, B. and A. B. McBratney, A.B.. 2010. Conditioned Latin Hypercube Sampling for Calibrating Soil Sensor Data to Soil Properties. In: *Proximal Soil Sensing, Progress in Soil Science*, pages 111-119.

\*For the cost-constrained implementation:

Roudier, P., Beaudette, D.E. and Hewitt, A.E. 2012. A conditioned Latin hypercube sampling algorithm incorporating operational constraints. In: *Digital Soil Assessments and Beyond. Proceedings of the 5th Global Workshop on Digital Soil Mapping, Sydney, Australia.*

### See Also

[plot.cLHS\\_result](#)

### Examples

```
df <- data.frame(
  a = runif(1000),
  b = rnorm(1000),
  c = sample(LETTERS[1:5], size = 1000, replace = TRUE)
)

# Returning the indices of the sampled points
res <- clhs(df, size = 50, iter = 100, progress = FALSE, simple = TRUE)
str(res)

# Returning a cLHS_result object for plotting
res <- clhs(df, size = 50, iter = 100, progress = FALSE, simple = FALSE)
str(res)
```

```
plot(res)

# Method DLHS with a linear increase of the strata weight (i.e. probability to be sampled)
# from 1 for the middle strata to 3 for the edge of the distribution
linear_increase <- 1+(2/24)*0:24
eta <- matrix(c(rev(linear_increase), linear_increase), ncol = 2, nrow = 50)
res <- clhs(df, size = 50, iter = 100, eta = eta, progress = FALSE, simple = FALSE)
str(res)
plot(res)
```

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cLHS\_result

*Conditioned Latin Hypercube Sampling result*

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## Description

A S3 class describing a cLHS result.

## Value

An object of class `cLHS_result` contains the following slots:

<code>index_samples</code>	a vector giving the indices of the chosen samples.
<code>sampled_data</code>	the sampled data.frame.
<code>obj</code>	a vector giving the evolution of the objective function throughout the Merropolis-Hastings iterations.
<code>cost</code>	a vector giving the evolution of the cost function throughout the Merropolis-Hastings iterations, if available, otherwise NULL.

## Author(s)

Pierre Roudier

## See Also

`clhs`

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plot.cLHS_result	<i>Plot cLHS results</i>
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## Description

Produces a plot illustrating the result of a cLHS sampling procedure.

## Usage

```
## S3 method for class 'cLHS_result'  
plot(x, modes = "obj", ...)
```

## Arguments

x	Object of class "cLHS_result".
modes	A character vector describing the plot to produce (see Details)
...	Other ggplot2 plotting parameters.

## Details

The subplots to be included in the final illustration are controlled by the mode option: - "obj" adds the evolution of the objective function over the iterations - "cost" adds the evolution of the cost function over the iterations (if available in x) - "hist" adds the comparison of the distributions of each variables in both the original object and the sampled result using histogram plots (for continuous variables). - "dens" adds the comparison of the distributions of each variables in both the original object and the sampled result using density plots (for continuous variables). - "box" adds the comparison of the distributions of each variables in both the original object and the sampled result using boxplots (for continuous variables).

## Author(s)

Pierre Roudier

## See Also

[clhs](#)

## Examples

```
df <- data.frame(  
  a = runif(1000),  
  b = rnorm(1000),  
  c = sample(LETTERS[1:5], size = 1000, replace = TRUE)  
)  
  
res <- clhs(df, size = 50, iter = 2000, progress = FALSE, simple = FALSE)
```

```
# You can plot only the objective function
plot(res, mode = "obj")

# Or you can compare the distribution in the original object
# and in the sampled result
plot(res, mode = c("obj", "box"))
```

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similarity\_buffer      *Gower similarity analysis*

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### Description

Calculates Gower's similarity index for every pixel within an given radius buffer of each sampling point

### Usage

```
similarity_buffer(covs, pts, buffer, fac = NA, metric = "gower",
  stand = FALSE, ...)
```

### Arguments

covs	raster stack of environmental covariates
pts	sampling points, object of class SpatialPointsDataframe
buffer	Radius of the disk around each point that similarity will be calculated
fac	numeric, can be > 1, (e.g., fac = c(2,3)). Raster layer(s) which are categorical variables. Set to NA if no factor is present
metric	character string specifying the similarity metric to be used. The currently available options are "euclidean", "manhattan" and "gower" (the default). See daisy from the cluster package for more details
stand	logical flag: if TRUE, then the measurements in x are standardized before calculating the dissimilarities.
...	passed to plyr::apply

### Value

a RasterStack

### Author(s)

Colby Brungard



**References**

Brungard, C. and Johanson, J. 2015. The gate's locked! I can't get to the exact sampling spot... can I sample nearby? *Pedometer*, 37:8–10.

**Examples**

```
library(raster)
library(sp)

data(meuse.grid)
coordinates(meuse.grid) = ~x+y
proj4string(meuse.grid) <- CRS("+init=epsg:28992")
gridded(meuse.grid) = TRUE
ms <- stack(meuse.grid)

suppressWarnings(RNGversion("3.5.0"))
set.seed(1)
pts <- clhs(ms, size = 3, iter = 100, progress = FALSE, simple = TRUE)
gw <- similarity_buffer(ms, pts, buffer = 500)
plot(gw)
```

# Index

\*Topic **sampling**

clhs-package, 2

clhs, 7

clhs (clhs.data.frame), 3

clhs-package, 2

clhs.data.frame, 3

cLHS\_result, 6

plot.cLHS\_result, 5, 7

similarity\_buffer, 8