

Package ‘ecodist’

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Title Dissimilarity-Based Functions for Ecological Analysis

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Description Dissimilarity-based analysis functions including ordination and Mantel test functions, intended for use with spatial and community ecological data. The original package description is in Goslee and Urban (2007) <[doi:10.18637/jss.v022.i07](https://doi.org/10.18637/jss.v022.i07)>, with further statistical detail in Goslee (2010) <[doi:10.1007/s11258-009-9641-0](https://doi.org/10.1007/s11258-009-9641-0)>.

License GPL (>= 2)

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Contents

ecodist-package	2
addord	4
bcdist	6
bump	7
bump.pmgram	8
cor2m	9
corgen	10

crosstab	11
dim.dist	13
distance	13
fixdmat	15
full	16
graze	17
iris.fit	19
iris.nmbs	20
iris.vf	21
iris.vfrot	22
lower	23
mantel	25
mgram	27
mgroup	29
min.nmbs	30
MRM	32
nmbs	33
pathdist	36
pco	37
plot.mgram	38
plot.nmbs	39
plot.vf	40
pmgram	42
relrange	45
residuals.mgram	46
rotate2d	47
vf	49
xdistance	50
xmantel	52
xmgram	54
z.no	57
z.z1	58
Index	61

Description

Dissimilarity-based analysis functions including ordination and Mantel test functions, intended for use with spatial and community data.

Details

This package contains well-established dissimilarity-based ecological analyses, such as [nmds](#) and [mantel](#), and experimental/research analyses such as [xmantel](#). Helper functions such as [crosstab](#) and [cor2m](#) facilitate analysis of community data.

Because many of the analyses are time-consuming, this package includes worked examples that can be loaded using `data()`.

Index of help topics:

MRM	Multiple Regression on distance Matrices
addord	Fit new points to an existing NMDS configuration.
bcdist	Bray-Curtis distance
bump	Nine-bump spatial pattern
bump.pmgram	Nine-bump spatial pattern
cor2m	Two-matrix correlation table
corgen	Generate correlated data
crosstab	Data formatting
dim.dist	Dimension of a distance object
distance	Calculate dissimilarity/distance metrics
ecodist-package	Dissimilarity-Based Functions for Ecological Analysis
fixdmat	Distance matrix conversion
full	Full symmetric matrix
graze	Site information and grazed vegetation data.
iris.fit	Example of adding to an ordination
iris.nmds	Example for nmds
iris.vf	Example for vector fitting on ordination
iris.vfrot	Example for vector fitting on rotated ordination
lower	Lower-triangular matrix
mantel	Mantel test
mgram	Mantel correlogram
mgroup	Mantel test for groups
min.nmds	Find minimum stress configuration
nmds	Non-metric multidimensional scaling
pathdist	Graph extension of dissimilarities
pco	Principal coordinates analysis
plot.mgram	Plot a Mantel correlogram
plot.nmds	Plot information about NMDS ordination
plot.vf	Plots fitted vectors onto an ordination diagram
pmgram	Piecewise multivariate correlogram
relnrange	Relativize a compositional data matrix.
residuals.mgram	Residuals of a Mantel correlogram
rotate2d	Rotate a 2D ordination.
vf	Vector fitting
xdistance	Cross-distance between two datasets.
xmantel	Cross-Mantel test
xmgram	Cross-Mantel correlogram

z.no	Example for pmgram
z.z1	Example for pmgram

Author(s)

Sarah Goslee and Dean Urban

Maintainer: Sarah Goslee <Sarah.Goslee@ars.usda.gov>

addord

Fit new points to an existing NMDS configuration.

Description

Uses a brute force algorithm to find the location for each new point that minimizes overall stress.

Usage

```
addord(origconf, fulldat, fulldist, isTrain, bfstep = 10, maxit = 50, epsilon = 1e-12)
```

Arguments

origconf	The original ordination configuration.
fulldat	The dataset containing original and new points.
fulldist	A dissimilarity matrix calculated on fulldat.
isTrain	A boolean vector of length nrow(fulldat) indicating which rows were training data used in determining origconf (TRUE), or are new points (FALSE).
bfstep	A tuning parameter for the brute force algorithm describing the size of grid to use.
maxit	The maximum number of iterations to use.
epsilon	Tolerance value for convergence.

Details

A region comprising the original ordination configuration plus one standard deviation is divided into a grid of bfstep rows and columns. For a new point, the grid cell with the lowest stress is identified. That cell is divided into a finer grid, and the lowest-stress cell identified. This process is repeated up to maxit times, or until stress changes less than epsilon.

Value

fullfitconf	The new ordination configuration containing training and new points.
stress	The stress value for each point.
isTrain	The boolean vector indicating training set membership, for reference.

Author(s)

Sarah Goslee

Examples

```
data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmds, file="ecodist/data/iris.nmds.rda")
data(iris.nmds)

# examine fit by number of dimensions
plot(iris.nmds)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmds, dims=2)

# rotate the configuration to maximize variance
iris.rot <- princomp(iris.nmin)$scores

# rotation preserves distance apart in ordination space
cor(dist(iris.nmin), dist(iris.rot))

# fit the data to the ordination as vectors
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vf <- vf(iris.nmin, iris[,1:4], nperm=1000)
### save(iris.vf, file="ecodist/data/iris.vf.rda")
data(iris.vf)

# repeat for the rotated ordination
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vfrot <- vf(iris.rot, iris[,1:4], nperm=1000)
### save(iris.vfrot, file="ecodist/data/iris.vfrot.rda")
data(iris.vfrot)

par(mfrow=c(1,2))
plot(iris.nmin, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="NMDS")
plot(iris.vf)
plot(iris.rot, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="Rotated NMDS")
plot(iris.vfrot)

##### addord example

# generate new data points to add to the ordination
```

```
# this might be new samples, or a second dataset

iris.new <- structure(list(Sepal.Length = c(4.6, 4.9, 5.4, 5.2, 6, 6.5, 6,
6.8, 7.3), Sepal.Width = c(3.2, 3.5, 3.6, 2.3, 2.8, 3, 2.7, 3.1,
3.2), Petal.Length = c(1.2, 1.5, 1.5, 3.5, 4.1, 4.2, 4.8, 5,
5.7), Petal.Width = c(0.26, 0.26, 0.26, 1.2, 1.3, 1.4, 1.8, 2,
2), Species = structure(c(1L, 1L, 1L, 2L, 2L, 2L, 3L, 3L, 3L), .Label = c("setosa",
"versicolor", "virginica"), class = "factor")), .Names = c("Sepal.Length",
"Sepal.Width", "Petal.Length", "Petal.Width", "Species"), class = "data.frame", row.names = c(NA,
-9L))

# provide a dist object containing original and new data
# provide a logical vector indicating which samples were used to
# construct the original configuration

iris.full <- rbind(iris, iris.new)
all.d <- dist(iris.full[,1:4])
is.orig <- c(rep(TRUE, nrow(iris)), rep(FALSE, nrow(iris.new)))

### addord() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.fit <- addord(iris.nmin, iris.full[,1:4], all.d, is.orig, maxit=100)
### save(iris.fit, file="ecodist/data/iris.fit.rda")
data(iris.fit)

plot(iris.fit$conf, col=iris.full$Species, pch=c(18, 4)[is.orig + 1], xlab="NMDS 1", ylab="NMDS 2")
title("Demo: adding points to an ordination")
legend("bottomleft", c("Training set", "Added point"), pch=c(4, 18))
legend("topright", levels(iris$Species), fill=1:3)
```

bcdist

Bray-Curtis distance

Description

Returns the Bray-Curtis (also known as Sorenson, 1 - percent similarity) pairwise distances for the objects in the data. It is duplicated by functionality within [distance](#) but remains for backward compatibility and because it is substantially faster.

Usage

```
bcdist(x, rmzero = FALSE)
```

Arguments

x matrix or data frame with rows as samples and columns as variables (such as species). Distances will be calculated for each pair of rows.

rmzero If `rmzero=TRUE`, empty rows will be removed from the data before distances are calculated. Otherwise, the distance between two empty rows is assumed to be 0 (the default).

Value

This function returns a column-order lower-triangular distance matrix. The returned object has an attribute, `Size`, giving the number of objects, that is, `nrow(x)`. The length of the vector that is returned is `nrow(x)*(nrow(x)-1)/2`.

Author(s)

Sarah Goslee

See Also

[dist](#), [distance](#)

Examples

```
data(graze)
system.time(graze.bc <- bcdist(graze[, -c(1:2)]))
# equivalent to but much faster than:
system.time(graze.bc2 <- distance(graze[, -c(1:2)], "bray-curtis"))

all.equal(graze.bc, graze.bc2)
```

bump

Nine-bump spatial pattern

Description

A two-dimensional artificial "landscape" illustrating the kind of spatial pattern that might be seen across mountain peaks.

Usage

```
data(bump)
```

Format

The format is: `int [1:25, 1:25] 2 2 2 2 2 2 2 2 2 ... - attr(*, "dimnames")=List of 2 ..$ : chr [1:25] "1" "3" "5" "7" ... ..$ : chr [1:25] "V1" "V3" "V5" "V7" ...`

Author(s)

Sarah Goslee

See Also

[bump.pmgram](#), [pmgram](#)

Examples

```
data(bump)
image(bump)
```

`bump.pmgram`

Nine-bump spatial pattern

Description

An object of class `mgram` for use in the example for [pmgram](#). Many of the functions in `ecodist` take a long time to run, so prepared examples have been included.

Usage

```
data(bump.pmgram)
```

Format

See [pmgram](#) for current format specification.

Author(s)

Sarah Goslee

See Also

[bump](#), [pmgram](#)

Examples

```
data(bump)

par(mfrow=c(1, 2))
image(bump, col=gray(seq(0, 1, length=5)))

z <- as.vector(bump)
x <- rep(1:25, times=25)
y <- rep(1:25, each=25)

X <- col(bump)
Y <- row(bump)
# calculate dissimilarities for data and space
geo.dist <- dist(cbind(as.vector(X), as.vector(Y)))
value.dist <- dist(as.vector(bump))
```



```

### pgram() is time-consuming, so this was generated
### in advance and saved.
### set.seed(1234)
### bump.pgram <- pgram(value.dist, geo.dist, nperm=10000)
### save(bump.pgram, file="ecodist/data/bump.pgram.rda")

data(bump.pgram)
plot(bump.pgram)

```

cor2m

*Two-matrix correlation table***Description**

Generate a correlation table between the variables of two data sets, originally for comparing species abundances and environmental variables.

Usage

```
cor2m(x, y, trim = TRUE, alpha = 0.05)
```

Arguments

x	A matrix or data frame of environmental (or other) variables matching the sites of x
y	A matrix or data frame of species (or other) variables
trim	If trim is TRUE, set rho<critical value(alpha) to 0
alpha	alpha p-value to use with trim, by default 0.05

Details

cor2m generates a correlation table between the variables of two matrices. The original use case is to compare species abundances and environmental variables. It results in a data frame with species (or the first matrix) as columns and environmental variables (or the second matrix) as rows, so it's easy to scan. Correlations less than a user-specified alpha (0.05 by default) can be set to NA. cor2m generates a correlation table between the variables of two matrices. The original use case is to compare species abundances and environmental variables. The result has species (or the first matrix) as columns and environmental variables (or the second matrix) as rows, so it's easy to scan. Correlations less than a user-specified alpha can be set to NA. If trim, correlations less than the critical value for the provided alpha are set to NA. The critical value is computed as a t-test with n-2 df. cor2m(x, y, trim=FALSE) is equivalent to cor(x, y)

Value

Returns a data frame of correlations between the variables of 2 data frames.

Author(s)

Dean Urban

Examples

```
data(graze)
speciesdata <- graze[, 3:7]
envdata <- graze[, 1:2]
sppenv.cor <- cor2m(envdata, speciesdata)
print(sppenv.cor, na.print="")
```

corgen

*Generate correlated data***Description**

Generate correlated data of a given length.

Usage

```
corgen(len, x, r, population = FALSE, epsilon = 0)
```

Arguments

len	Length of vectors.
x	Independent data. If x is specified, the population parameter is automatically set to TRUE.
r	Desired correlation between data vectors.
population	TRUE for vectors drawn from two populations with correlation r, otherwise r is the sample correlation.
epsilon	Desired tolerance.

Details

Either x or len must be specified. If epsilon = 0, it has no effect, otherwise the sampling process is repeated until the sample correlation is within epsilon of r. This option allows the production of exactly-correlated data, within the limits of epsilon. Setting epsilon > 0 invalidates the population setting; data will be correlated within that range, rather than sampled from that population. If epsilon = 0, it has no effect, otherwise the sampling process is repeated until the sample correlation is within epsilon of r. This option allows the production of exactly-correlated data, within the limits of epsilon. Setting epsilon > 0 invalidates the population setting; data will be correlated within that range, rather than sampled from that population. If epsilon = 0, it has no effect, otherwise the sampling process is repeated until the sample correlation is within epsilon of r. This option allows the production of exactly-correlated data, within the limits of epsilon. Setting epsilon > 0 invalidates the population setting; data will be correlated within that range, rather than sampled from that population.

Value

x	First data vector, either generated by corgen or given by the user.
y	Second data vector.

Author(s)

Sarah Goslee

Examples

```
# create two random variables of length 100 with correlation
# of 0.10 +/- 0.01
xy <- corgen(len=100, r=.1, epsilon=0.01)
with(xy, cor(x, y))

# create two random variables of length 100 drawn from a population with
# a correlation of -0.82
xy <- corgen(len=100, r=-0.82, population=TRUE)
with(xy, cor(x, y))

# create a variable y within 0.01 of the given correlation to x
x <- 1:100
y <- corgen(x=x, r=.5, epsilon=.01)$y
cor(x, y)
```

crosstab

Data formatting

Description

Converts field data of the form site, species, observation into a site by species data frame.

Usage

```
crosstab(rowlab, collab, values, type = "sum", data, allrows, allcols,
na.as.0 = TRUE, check.names = TRUE, ...)
```

Arguments

rowlab	row labels, e.g. site names.
collab	column labels, e.g. species names.
values	data values.
data	optional data frame from which to take rowlab, collab and/or values.
type	function to use to combine data, one of "sum" (default), "min", "max", "mean", "count".
allrows	optional, list of all desired row names that may not appear in rowlab.

<code>allcols</code>	optional, list of all desired column names that may not appear in <code>collab</code> .
<code>na.as.0</code>	if TRUE, all NA values are replaced with 0.
<code>check.names</code>	if FALSE, data frame names are not checked for syntactic validity, so that they match the input categories. Otherwise <code>make.names()</code> is used to adjust them.
<code>...</code>	optional arguments to the function specified in <code>type</code> , such as <code>na.rm=TRUE</code>

Details

Field data are often recorded as a separate row for each site-species combination. This function reformats such data into a data frame for further analysis based on unique row and column labels. The three vectors should all be the same length (including duplicates). The three vectors may also be provided as names of columns in the data frame specified by the `data` argument.

If `allrows` or `allcols` exists, rows and/or columns of zeros are inserted for any elements of `allrows/allcols` not present in `rowlab/collab`.

If `values` is missing the number of occurrences of combinations of `rowlab` and `collab` will be returned. Thus, `crosstab(rowlab, collab)` is equivalent to `table(rowlab, collab)`.

If `type` is "count", the unique combinations of `rowlab`, `collab` and `values` will be returned.

Value

data frame with `rowlab` as row headings, `collab` as columns, and `values` as the data.

Author(s)

Sarah Goslee

Examples

```
# Make a random example
plotnames <- rep(1:5, each = 6)
speciesnames <- rep(c("A", "B", "C"), 10)
freqdata <- runif(30)

# number of samples of each species and plot
crosstab(plotnames, speciesnames)

# can use the data argument
speciesdata <- data.frame(plots = plotnames, species = speciesnames,
  freq = freqdata, stringsAsFactors=FALSE)

# mean frequency by species and plot
crosstab(plots, species, freq, data=speciesdata, type="mean")

# can specify additional possible row or column levels
crosstab(plots, species, freq, data=speciesdata, type="mean", allcols=LETTERS[1:5])
```

dim.dist	<i>Dimension of a distance object</i>
----------	---------------------------------------

Description

Returns NULL for the dimensions of a distance object.

Usage

```
## S3 method for class 'dist'
dim(x)
```

Arguments

x object of class dist

Details

The spdep package overwrites the base R behavior of dim.dist() to return c(n, n) where n is the size of the full matrix. The base R behavior returns NULL. This function restores base R behavior within ecodist, because otherwise spdep being loaded breaks ecodist functionality.

Value

NULL

Author(s)

Sarah Goslee

Examples

```
data(graze)
dim(dist(graze))
```

distance	<i>Calculate dissimilarity/distance metrics</i>
----------	---

Description

This function calculates a variety of dissimilarity or distance metrics. Although it duplicates the functionality of dist() and bcdist(), it is written in such a way that new metrics can easily be added. distance() was written for extensibility and understandability, and is not necessarily an efficient choice for use with large matrices.

Usage

```
distance(x, method = "euclidean", sprange=NULL, spweight=NULL, icov, inverted = FALSE)
```

Arguments

<code>x</code>	matrix or data frame with rows as samples and columns as variables (such as species). Distances will be calculated for each pair of rows.
<code>method</code>	Currently 7 dissimilarity metrics can be calculated: "euclidean", "bray-curtis", "manhattan", "mahalanobis" (squared Mahalanobis distance), "jaccard", "difference", "sorensen", "gower", "modgower10" (modified Gower, base 10), "modgower2" (modified Gower, base 2). Partial matching will work for selecting a method.
<code>sprange</code>	Gower dissimilarities offer the option of dividing by the species range. If <code>sprange=NULL</code> no range is used. If <code>sprange</code> is a vector of length <code>nrow(x)</code> it is used for standardizing the dissimilarities.
<code>spweight</code>	Euclidean, Manhattan, and Gower dissimilarities allow weighting. If <code>spweight=NULL</code> , no weighting is used. If <code>spweight="absence"</code> , then $W=0$ if both species are absent and 1 otherwise, thus deleting joint absences.
<code>icov</code>	Optional covariance matrix; only used if <code>method="mahalanobis"</code> since Mahalanobis distance requires calculating the variance-covariance matrix for the entire dataset. Providing <code>icov</code> directly makes it possible to calculate distances for a subset of the full dataset.
<code>inverted</code>	If TRUE, the optional covariance matrix for <code>method="mahalanobis"</code> is not inverted before solving. Providing an inverted matrix may speed up calculations.

Value

Returns a lower-triangular distance matrix as an object of class "dist".

Author(s)

Sarah Goslee

See Also

[dist](#), [bcdist](#)

Examples

```
data(iris)
iris.bc <- distance(iris[, 1:4], "bray-curtis")

# The effect of specifying icov:

# calculate Mahalanobis distance for the full iris dataset
iris.md <- full(distance(iris[, 1:4], "mahal"))
iris.md[1, 2] # Mahalanobis distance between samples 1 and 2
```

```
# calculate Mahalanobis for just one species
setosa.md <- full(distance(iris[iris$Species == "setosa", 1:4], "mahal"))
setosa.md[1, 2] # Mahalanobis distance between samples 1 and 2

# use the covariance matrix for the full dataset to scale for one species
setosa.scaled.md <- full(distance(iris[iris$Species == "setosa", 1:4],
  "mahal", icov=var(iris[,1:4])))
setosa.scaled.md[1, 2] # Mahalanobis distance between samples 1 and 2
```

fixdmat	<i>Distance matrix conversion</i>
---------	-----------------------------------

Description

Convert a row-order lower-triangular distance matrix to a full symmetric matrix.

Usage

```
fixdmat(v)
```

Arguments

`v` lower-triangular distance matrix in row order.

Details

R distance functions such as `dist` and `bcdist` return a lower triangular distance matrix in column order. Some other programs return the lower triangular matrix in row order. To use this matrix in R functions, it must be converted from row order to column order.

Value

full symmetric distance matrix.

Author(s)

Sarah Goslee

See Also

[lower](#), [full](#)

Examples

```
x.vec <- seq_len(6)
x.vec

# Make an R-style column order symmetric matrix
full(x.vec)

# Extract the lower triangle from a symmetric matrix
# in column order
lower(full(x.vec))

# Convert to or from a row order symmetric matrix
fixdmat(x.vec)
lower(fixdmat(x.vec))

fixdmat(c(1, 2, 4, 3, 5, 6))
```

full	<i>Full symmetric matrix</i>
------	------------------------------

Description

Convert a column order distance matrix to a full symmetric matrix.

Usage

```
full(v)
```

Arguments

`v` lower-triangular column order distance matrix.

Details

Converts a column order lower-triangular distance matrix as written by R functions into a symmetric matrix. Note that `lower()` used on a 1x1 matrix will return the single element, which may not be the correct behavior in all cases, while `full()` used on a single element will return a 2x2 matrix.

Value

full symmetric matrix.

Author(s)

Sarah Goslee

See Also

[lower](#), [fixdmat](#)

Examples

```
# Given a vector:
x.vec <- seq_len(6)
x.vec

# Make an R-style column order symmetric matrix
full(x.vec)

# Extract the lower triangle from a symmetric matrix
# in column order
lower(full(x.vec))

# Convert to or from a row order symmetric matrix
fixdmat(x.vec)
lower(fixdmat(x.vec))

fixdmat(c(1, 2, 4, 3, 5, 6))
```

graze

Site information and grazed vegetation data.

Description

This data frame contains site location, landscape context and dominant plant species abundances for 25 of the plant species found in 50 grazed pastures in the northeastern United States. Elements are the mean values for canopy cover for ten 0.5 x 2 m quadrats.

Usage

```
data(graze)
```

Format

A data frame with 50 observations on the following 25 variables.

sitelocation Site location along a geographic gradient.

forestpct Percentage forest cover within a 1-km radius.

ACMI2 Percentage canopy cover.

ANOD Percentage canopy cover.

ASSY Percentage canopy cover.

BRIN2 Percentage canopy cover.

CIAR4 Percentage canopy cover.

CIIN Percentage canopy cover.

CIVU Percentage canopy cover.

DAGL Percentage canopy cover.

ELRE4 Percentage canopy cover.
GAM0 Percentage canopy cover.
LOAR10 Percentage canopy cover.
LOC06 Percentage canopy cover.
LOPE Percentage canopy cover.
OXST Percentage canopy cover.
PLMA2 Percentage canopy cover.
POPR Percentage canopy cover.
PRVU Percentage canopy cover.
RAAC3 Percentage canopy cover.
RUCR Percentage canopy cover.
SORU2 Percentage canopy cover.
STGR Percentage canopy cover.
TAOF Percentage canopy cover.
TRPR2 Percentage canopy cover.
TRRE3 Percentage canopy cover.
VEOF2 Percentage canopy cover.

Details

Site locations fall along a southwest-northeast transect through the northeastern United States. This is a synthetic gradient calculated from latitude and longitude. Forest landcover is taken from the USGS 1992 National Land Cover Dataset. All forest classes were combined, and the percentage within 1 km of the sample sites was calculated using a GIS.

Author(s)

Sarah Goslee

Source

Details of these data are available in Tracy and Sanderson (2000) and Goslee and Sanderson (2010). The 1992 NLCD data can be obtained from <http://www.mrlc.gov/>. Species codes are from <http://plants.usda.gov> (2010).

References

Tracy, B.F. and M.A. Sanderson. 2000. Patterns of plant species richness in pasture lands of the northeast United States. *Plant Ecology* 149:169-180.

Goslee, S.C., Sanderson, M.A. 2010. Landscape Context and Plant Community Composition in Grazed Agricultural Systems. *Landscape Ecology* 25:1029-1039.

Examples

```
data(graze)
```

iris.fit

*Example of adding to an ordination***Description**

A fitted ordination for use in the example for [addord](#). Many of the functions in `ecodist` take a long time to run, so prepared examples have been included.

Usage

```
data(iris.fit)
```

Format

The format of this object is a list with: X1, X2, etc: ordination configuration: coordinates for each point. stress: goodness of fit for each point. isTrain: logical vector indicating whether each point was used in the original ordination.

Author(s)

Sarah Goslee

See Also

[nmds](#), [addord](#)

Examples

```
data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmds, file="ecodist/data/iris.nmds.rda")
data(iris.nmds)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmds, dims=2)

# generate new data points to add to the ordination
# this might be new samples, or a second dataset

iris.new <- structure(list(Sepal.Length = c(4.6, 4.9, 5.4, 5.2, 6, 6.5, 6,
6.8, 7.3), Sepal.Width = c(3.2, 3.5, 3.6, 2.3, 2.8, 3, 2.7, 3.1,
3.2), Petal.Length = c(1.2, 1.5, 1.5, 3.5, 4.1, 4.2, 4.8, 5,
5.7), Petal.Width = c(0.26, 0.26, 0.26, 1.2, 1.3, 1.4, 1.8, 2,
2), Species = structure(c(1L, 1L, 1L, 2L, 2L, 2L, 3L, 3L, 3L), .Label = c("setosa",
```

```

"versicolor", "virginica"), class = "factor")), .Names = c("Sepal.Length",
"Sepal.Width", "Petal.Length", "Petal.Width", "Species"), class = "data.frame",
row.names = c(NA, -9L))

# provide a dist object containing original and new data
# provide a logical vector indicating which samples were used to
# construct the original configuration

iris.full <- rbind(iris, iris.new)
all.d <- dist(iris.full[,1:4])
is.orig <- c(rep(TRUE, nrow(iris)), rep(FALSE, nrow(iris.new)))

### addord() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.fit <- addord(iris.nmin, iris.full[,1:4], all.d, is.orig, maxit=100)
### save(iris.fit, file="ecodist/data/iris.fit.rda")
data(iris.fit)

plot(iris.fit$conf, col=iris.full$Species, pch=c(18, 4)[is.orig + 1],
     xlab="NMDS 1", ylab="NMDS 2")
title("Demo: adding points to an ordination")
legend("bottomleft", c("Training set", "Added point"), pch=c(4, 18))
legend("topright", levels(iris$Species), fill=1:3)

```

iris.nmds

Example for nmds

Description

An object of class `nmds` for use in the example for [nmds](#). Many of the functions in `ecodist` take a long time to run, so prepared examples have been included.

Usage

```
data(iris.nmds)
```

Format

See [nmds](#) for current format specification.

Author(s)

Sarah Goslee

See Also

[nmds](#)

Examples

```
data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmds, file="ecodist/data/iris.nmds.rda")
data(iris.nmds)

# examine fit by number of dimensions
plot(iris.nmds)
```

iris.vf

Example for vector fitting on ordination

Description

An object of class vf for use in the examples for [nmds](#) and [vf](#). Many of the functions in `ecodist` take a long time to run, so prepared examples have been included.

Usage

```
data(iris.vf)
```

Format

See [vf](#) for current format specification.

Author(s)

Sarah Goslee

See Also

[nmds](#), [vf](#)

Examples

```
data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
```

```

### save(iris.nmbs, file="ecodist/data/iris.nmbs.rda")
data(iris.nmbs)

# examine fit by number of dimensions
plot(iris.nmbs)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmbs, dims=2)

# rotate the configuration to maximize variance
iris.rot <- princomp(iris.nmin)$scores

# rotation preserves distance apart in ordination space
cor(dist(iris.nmin), dist(iris.rot))

# fit the data to the ordination as vectors
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vf <- vf(iris.nmin, iris[,1:4], nperm=1000)
### save(iris.vf, file="ecodist/data/iris.vf.rda")
data(iris.vf)

plot(iris.nmin, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="NMDS")
plot(iris.vf)

```

iris.vfrot

Example for vector fitting on rotated ordination

Description

An object of class vf for use in the examples for [nmbs](#) and [vf](#). Many of the functions in ecodist take a long time to run, so prepared examples have been included.

Usage

```
data(iris.vfrot)
```

Format

See [vf](#) for current format specification.

Author(s)

Sarah Goslee

See Also

[nmbs](#), [vf](#)

Examples

```

data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmds, file="ecodist/data/iris.nmds.rda")
data(iris.nmds)

# examine fit by number of dimensions
plot(iris.nmds)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmds, dims=2)

# rotate the configuration to maximize variance
iris.rot <- princomp(iris.nmin)$scores

# rotation preserves distance apart in ordination space
cor(dist(iris.nmin), dist(iris.rot))

# fit the data to the ordination as vectors
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vf <- vf(iris.nmin, iris[,1:4], nperm=1000)
### save(iris.vf, file="ecodist/data/iris.vf.rda")
data(iris.vf)

# repeat for the rotated ordination
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vfrot <- vf(iris.rot, iris[,1:4], nperm=1000)
### save(iris.vfrot, file="ecodist/data/iris.vfrot.rda")
data(iris.vfrot)

par(mfrow=c(1,2))
plot(iris.nmin, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="NMDS")
plot(iris.vf)
plot(iris.rot, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="Rotated NMDS")
plot(iris.vfrot)

```

Description

Convert a symmetric distance matrix to a column order lower triangular matrix.

Usage

```
lower(m)
```

Arguments

`m` a symmetric distance matrix.

Details

Converts a symmetric matrix, for example a dissimilarity matrix, into a column order lower-triangular matrix. This may be useful to format the input for certain clustering and ordination functions. Note that `lower()` used on a 1x1 matrix will return the single element, which may not be the correct behavior in all cases, while `full()` used on a single element will return a 2x2 matrix.

Value

column order lower triangular matrix.

Author(s)

Sarah Goslee

See Also

[full](#), [fixdmat](#)

Examples

```
x.vec <- seq_len(6)
x.vec

# Make an R-style column order symmetric matrix
full(x.vec)

# Extract the lower triangle from a symmetric matrix
# in column order
lower(full(x.vec))

# Convert to or from a row order symmetric matrix
fixdmat(x.vec)
lower(fixdmat(x.vec))

fixdmat(c(1, 2, 4, 3, 5, 6))
```

mantel	<i>Mantel test</i>
--------	--------------------

Description

Simple and partial Mantel tests, with options for ranked data, permutation tests, and bootstrapped confidence limits.

Usage

```
mantel(formula = formula(data), data, nperm = 1000,
       mrank = FALSE, nboot = 500, pboot = 0.9, cboot = 0.95)
```

Arguments

formula	formula describing the test to be conducted. For this test, $y \sim x$ will perform a simple Mantel test, while $y \sim x + z1 + z2 + z3$ will do a partial Mantel test of the relationship between x and y given $z1$, $z2$, $z3$. All variables can be either a distance matrix of class <code>dist</code> or vectors of dissimilarities.
data	an optional dataframe containing the variables in the model as columns of dissimilarities. By default the variables are taken from the current environment.
nperm	number of permutations to use. If set to 0, the permutation test will be omitted.
mrnk	if this is set to <code>FALSE</code> (the default option), Pearson correlations will be used. If set to <code>TRUE</code> , the Spearman correlation (correlation ranked distances) will be used.
nboot	number of iterations to use for the bootstrapped confidence limits. If set to 0, the bootstrapping will be omitted.
pboot	the level at which to resample the data for the bootstrapping procedure.
cboot	the level of the confidence limits to estimate.

Details

If only one independent variable is given, the simple Mantel r (r_{12}) is calculated. If more than one independent variable is given, the partial Mantel r ($r_{y|x_1 \dots}$) is calculated by permuting one of the original dissimilarity matrices. The bootstrapping is actually resampling without replacement, because duplication of samples is not useful in a dissimilarity context (the dissimilarity of a sample with itself is zero). Resampling within dissimilarity values is inappropriate, just as for permutation.

Value

mantelr	Mantel coefficient.
pval1	one-tailed p-value (null hypothesis: $r \leq 0$).
pval2	one-tailed p-value (null hypothesis: $r \geq 0$).
pval3	two-tailed p-value (null hypothesis: $r = 0$).
llim	lower confidence limit.
ulim	upper confidence limit.

Author(s)

Sarah Goslee

References

- Mantel, N. 1967. The detection of disease clustering and a generalized regression approach. *Cancer Research* 27:209-220.
- Smouse, P.E., J.C. Long and R.R. Sokal. 1986. Multiple regression and correlation extensions of the Mantel test of matrix correspondence. *Systematic Zoology* 35:627-632.
- Goslee, S.C. and Urban, D.L. 2007. The ecodist package for dissimilarity-based analysis of ecological data. *Journal of Statistical Software* 22(7):1-19.
- Goslee, S.C. 2010. Correlation analysis of dissimilarity matrices. *Plant Ecology* 206(2):279-286.

See Also

[mgram](#), [mgroup](#)

Examples

```
data(graze)

grasses <- graze[, colnames(graze) %in% c("DAGL", "LOAR10", "LOPE", "POPR")]
legumes <- graze[, colnames(graze) %in% c("LOC06", "TRPR2", "TRRE3")]

grasses.bc <- bcdist(grasses)
legumes.bc <- bcdist(legumes)

space.d <- dist(graze$siteLocation)
forest.d <- dist(graze$forestpct)

# Mantel test: is the difference in forest cover between sites
# related to the difference in grass composition between sites?
mantel(grasses.bc ~ forest.d)

# Mantel test: is the geographic distance between sites
# related to the difference in grass composition between sites?
mantel(grasses.bc ~ space.d)

# Partial Mantel test: is the difference in forest cover between sites
# related to the difference in grass composition once the
# linear effects of geographic distance are removed?
mantel(grasses.bc ~ forest.d + space.d)

# Mantel test: is the difference in forest cover between sites
# related to the difference in legume composition between sites?
mantel(legumes.bc ~ forest.d)

# Mantel test: is the geographic distance between sites
# related to the difference in legume composition between sites?
```

```

mantel(legumes.bc ~ space.d)

# Partial Mantel test: is the difference in forest cover between sites
# related to the difference in legume composition once the
# linear effects of geographic distance are removed?
mantel(legumes.bc ~ forest.d + space.d)

# Is there nonlinear pattern in the relationship with geographic distance?
par(mfrow=c(2, 1))
plot(mgram(grasses.bc, space.d, nclass=8))
plot(mgram(legumes.bc, space.d, nclass=8))

```

mgram

*Mantel correlogram***Description**

Calculates simple Mantel correlograms.

Usage

```

mgram(species.d, space.d, breaks, nclass, stepsize, equiprobable = FALSE, nperm = 1000,
      mrank = FALSE, nboot = 500, pboot = 0.9, cboot = 0.95,
      alternative = "two.sided", trace = FALSE)

```

Arguments

species.d	lower-triangular dissimilarity matrix.
space.d	lower-triangular matrix of geographic distances.
breaks	locations of class breaks. If specified, overrides nclass and stepsize.
nclass	number of distance classes. If not specified, Sturge's rule will be used to determine an appropriate number of classes.
stepsize	width of each distance class. If not specified, nclass and the range of space.d will be used to calculate an appropriate default.
equiprobable	if TRUE, create nclass classes of equal number of distances; if FALSE, create nclass classes of equal width
nperm	number of permutations to use. If set to 0, the permutation test will be omitted.
mrnk	if this is set to FALSE (the default option), Pearson correlations will be used. If set to TRUE, the Spearman correlation (correlation ranked distances) will be used.
nboot	number of iterations to use for the bootstrapped confidence limits. If set to 0, the bootstrapping will be omitted.
pboot	the level at which to resample the data for the bootstrapping procedure.
cboot	the level of the confidence limits to estimate.

alternative	default is "two.sided", and returns p-values for $H_0: r_M = 0$. The alternative is "one.sided", which returns p-values for $H_0: r_M \leq 0$.
trace	if TRUE, returns progress indicators.

Details

This function calculates Mantel correlograms, and tests the hypothesis that the mean compositional dissimilarity within a distance class differs from the mean of all the other distance classes combined. The Mantel correlogram is essentially a multivariate autocorrelation function. The Mantel r represents the dissimilarity in variable composition (often species composition) at a particular lag distance, and significance is tested in reference to all distance classes.

Value

Returns an object of class `mgram`, which is a list with two elements. `mgram` is a matrix with one row for each distance class and 6 columns:

lag	midpoint of the distance class.
ngroup	number of distances in that class.
mantelr	Mantel r value.
pval	p-value for the test chosen.
llim	lower bound of confidence limit for mantelr.
ulim	upper bound of confidence limit for mantelr.

`resids` is NA for objects calculated by `mgram()`.

Author(s)

Sarah Goslee

References

Legendre, P. and M. Fortin. 1989. Spatial pattern and ecological analysis. *Vegetatio* 80:107-138.

See Also

[mantel](#), [plot.mgram](#), [pmgram](#)

Examples

```
# generate a simple surface
x <- matrix(1:10, nrow=10, ncol=10, byrow=FALSE)
y <- matrix(1:10, nrow=10, ncol=10, byrow=TRUE)
z <- x + 3*y
image(z)

# analyze the pattern of z across space
space <- cbind(as.vector(x), as.vector(y))
z <- as.vector(z)
```

```

space.d <- distance(space, "eucl")
z.d <- distance(z, "eucl")
z.mgram <- mgram(z.d, space.d, nperm=0)
plot(z.mgram)

#

data(graze)
space.d <- dist(graze$sitelocation)
forest.d <- dist(graze$forestpct)

grasses <- graze[, colnames(graze) %in% c("DAGL", "LOAR10", "LOPE", "POPR")]
legumes <- graze[, colnames(graze) %in% c("LOC06", "TRPR2", "TRRE3")]

grasses.bc <- bcdist(grasses)
legumes.bc <- bcdist(legumes)

# Does the relationship of composition with distance vary for
# grasses and legumes?
par(mfrow=c(2, 1))
plot(mgram(grasses.bc, space.d, nclass=8))
plot(mgram(legumes.bc, space.d, nclass=8))

```

mgroup

Mantel test for groups

Description

Mantel test across one or more group contrasts.

Usage

```
mgroup(edist, groups, nperm = 1000, mrank = FALSE)
```

Arguments

edist	a dist object or lower triangular distance vector.
groups	a vector of group memberships (numeric, character, or factor), or a matrix or data frame with columns describing multiple sets of groups.
nperm	number of permutations to use. If set to 0, the permutation test will be omitted.
mrnk	if this is set to FALSE (the default option), Pearson correlations will be used. If set to TRUE, the Spearman correlation (correlation ranked distances) will be used.

Details

mgroup returns the Mantel correlations for group contrast matrices computed from cluster groups across a range of clustering levels.

Value

nclust	Number of groups tested.
mantelr	Mantel coefficient.
pval1	one-tailed p-value (null hypothesis: $r \leq 0$).

Author(s)

Sarah Goslee

References

Legendre, P. and M. Fortin. 1989. Spatial pattern and ecological analysis. *Vegetatio* 80:107-138.

See Also

[mantel](#)

Examples

```
# Using a model matrix to test group membership

data(iris)
iris.d <- dist(iris[,1:4])
mgroup(iris.d, iris[,5])

# clustering-based example

data(graze)
graze.d <- dist(graze[, -c(1:2)])
graze.hclust <- hclust(graze.d)

clust.groups <- data.frame(
  k2 = cutree(graze.hclust, k = 2),
  k4 = cutree(graze.hclust, k = 4),
  k6 = cutree(graze.hclust, k = 6),
  k8 = cutree(graze.hclust, k = 8))

mgroup(graze.d, clust.groups, nperm=1000)
```

min.nmnds

Find minimum stress configuration

Description

Finds minimum stress configuration from output of nmnds()

Usage

```
## S3 method for class 'nmnds'
min(..., na.rm = FALSE, dims = 2)
nmnds.min(x, dims = 2)
```

Arguments

...	output from nmnds()
x	output from nmnds()
dims	desired dimensionality of result. If <code>dims = 0</code> then the overall minimum stress configuration is chosen. By default, the best two-dimensional configuration is returned.
na.rm	Not used; there should be no NA values in a NMDS configuration.

Details

For back-compatibility, the `nmnds.min` function remains.

Value

Configuration of minimum stress ordination (dataframe of coordinates). The stress and r^2 for the minimum stress configuration are stored as attributes.

Author(s)

Sarah Goslee

See Also

[nmnds](#)

Examples

```
data(iris)
iris.d <- dist(iris[,1:4])

### nmnds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmnds <- nmnds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmnds, file="ecodist/data/iris.nmnds.rda")
data(iris.nmnds)

# examine fit by number of dimensions
plot(iris.nmnds)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmnds, dims=2)
```

MRM

*Multiple Regression on distance Matrices***Description**

Multiple regression on distance matrices (MRM) using permutation tests of significance for regression coefficients and R-squared.

Usage

```
MRM(formula = formula(data), data, nperm = 1000,
method = "linear", mrank = FALSE)
```

Arguments

formula	formula describing the test to be conducted.
data	an optional dataframe containing the variables in the model as columns of dissimilarities. By default the variables are taken from the current environment.
nperm	number of permutations to use. If set to 0, the permutation test will be omitted.
mrnk	if this is set to FALSE (the default option), Pearson correlations will be used. If set to TRUE, the Spearman correlation (correlation ranked distances) will be used.
method	if "linear", the default, uses multiple regression analysis. If "logistic", performs logistic regression with appropriate permutation testing. Note that this may be substantially slower.

Details

Performs multiple regression on distance matrices following the methods outlined in Legendre et al. 1994. Specifically, the permutation test uses a pseudo-t test to assess significance, rather than using the regression coefficients directly.

Value

coef	A matrix with regression coefficients and associated p-values from the permutation test (using the pseudo-t of Legendre et al. 1994).
r.squared	Regression R-squared and associated p-value from the permutation test (linear only).
F.test	F-statistic and p-value for overall F-test for lack of fit (linear only).
dev	Residual deviance, degrees of freedom, and associated p-value (logistic only).

Author(s)

Sarah Goslee

References

- Lichstein, J. 2007. Multiple regression on distance matrices: A multivariate spatial analysis tool. *Plant Ecology* 188: 117-131.
- Legendre, P.; Lapointe, F. and Casgrain, P. 1994. Modeling brain evolution from behavior: A permutational regression approach. *Evolution* 48: 1487-1499.

See Also

[mantel](#)

Examples

```
data(graze)

# Abundance of this grass is related to forest cover but not location
MRM(dist(LOAR10) ~ dist(sitelocation) + dist(forestpct), data=graze, nperm=10)

# Abundance of this legume is related to location but not forest cover
MRM(dist(TRRE3) ~ dist(sitelocation) + dist(forestpct), data=graze, nperm=10)

# Compare to presence/absence of grass LOAR10 using logistic regression
LOAR10.presence <- ifelse(graze$LOAR10 > 0, 1, 0)
MRM(dist(LOAR10.presence) ~ dist(sitelocation) + dist(forestpct),
     data=graze, nperm=10, method="logistic")
```

nmds

Non-metric multidimensional scaling

Description

Non-metric multidimensional scaling.

Usage

```
nmds(dmat, mindim = 1, maxdim = 2, nits = 10, iconf, epsilon = 1e-12,
     maxit = 500, trace = FALSE)
```

Arguments

dmat	lower-triangular dissimilarity matrix.
mindim	optional, minimum number of dimensions to use.
maxdim	optional, maximum number of dimensions to use.
nits	optional, number of separate ordinations to use.
iconf	optional, initial configuration. If not specified, then a random configuration is used.
epsilon	optional, acceptable difference in stress.
maxit	optional, maximum number of iterations.
trace	if TRUE, will write progress indicator to the screen.

Details

The goal of NMDS is to find a configuration in a given number of dimensions which preserves rank-order dissimilarities as closely as possible. The number of dimensions must be specified in advance. Because NMDS is prone to finding local minima, several random starts must be used. Stress is used as the measure of goodness of fit. A lower stress indicates a better match between dissimilarity and ordination. As of *ecodist* 1.9, the stress calculation used is the same as in *MASS: isoMDS*. In previous versions it was monotonically related, so the same configurations were produced, but the absolute value was different.

Value

<code>conf</code>	list of configurations, each in the same units as the original dissimilarities.
<code>stress</code>	list of final stress values.
<code>r2</code>	total variance explained by each configuration.

The first results are for the lowest number of dimensions (total number is $(\text{mindim} - \text{maxdim} + 1) * \text{nits}$).

Author(s)

Sarah Goslee

References

Kruskal, J.B. 1964. Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. *Psychometrika* 29:1-27.

Minchin, P.R. 1987. An evaluation of the relative robustness of techniques for ecological ordination. *Vegetatio* 96:89-108.

See Also

[plot.nmds](#), [min.nmds](#), [vf](#), [addord](#)

Examples

```
data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmds, file="ecodist/data/iris.nmds.rda")
data(iris.nmds)

# examine fit by number of dimensions
plot(iris.nmds)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmds, dims=2)
```

```

# rotate the configuration to maximize variance
iris.rot <- princomp(iris.nmin)$scores

# rotation preserves distance apart in ordination space
cor(dist(iris.nmin), dist(iris.rot))

# fit the data to the ordination as vectors
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vf <- vf(iris.nmin, iris[,1:4], nperm=1000)
### save(iris.vf, file="ecodist/data/iris.vf.rda")
data(iris.vf)

# repeat for the rotated ordination
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vfrot <- vf(iris.rot, iris[,1:4], nperm=1000)
### save(iris.vfrot, file="ecodist/data/iris.vfrot.rda")
data(iris.vfrot)

par(mfrow=c(1,2))
plot(iris.nmin, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="NMDS")
plot(iris.vf)
plot(iris.rot, col=as.numeric(iris$Species), pch=as.numeric(iris$Species),
     main="Rotated NMDS")
plot(iris.vfrot)

# generate new data points to add to the ordination
# this might be new samples, or a second dataset

iris.new <- structure(list(Sepal.Length = c(4.6, 4.9, 5.4, 5.2, 6, 6.5, 6,
6.8, 7.3), Sepal.Width = c(3.2, 3.5, 3.6, 2.3, 2.8, 3, 2.7, 3.1,
3.2), Petal.Length = c(1.2, 1.5, 1.5, 3.5, 4.1, 4.2, 4.8, 5,
5.7), Petal.Width = c(0.26, 0.26, 0.26, 1.2, 1.3, 1.4, 1.8, 2,
2), Species = structure(c(1L, 1L, 1L, 2L, 2L, 2L, 3L, 3L, 3L), .Label = c("setosa",
"versicolor", "virginica"), class = "factor")), .Names = c("Sepal.Length",
"Sepal.Width", "Petal.Length", "Petal.Width", "Species"), class = "data.frame",
row.names = c(NA, -9L))

# provide a dist object containing original and new data
# provide a logical vector indicating which samples were used to
# construct the original configuration

iris.full <- rbind(iris, iris.new)
all.d <- dist(iris.full[,1:4])
is.orig <- c(rep(TRUE, nrow(iris)), rep(FALSE, nrow(iris.new)))

### addord() is timeconsuming, so this was generated
### in advance and saved.

```

```

### set.seed(1234)
### iris.fit <- addord(iris.nmin, iris.full[,1:4], all.d, is.orig, maxit=100)
### save(iris.fit, file="ecodist/data/iris.fit.rda")
data(iris.fit)

plot(iris.fit$conf, col=iris.full$Species, pch=c(18, 4)[is.orig + 1],
     xlab="NMDS 1", ylab="NMDS 2")
title("Demo: adding points to an ordination")
legend("bottomleft", c("Training set", "Added point"), pch=c(4, 18))
legend("topright", levels(iris$Species), fill=1:3)

```

pathdist

Graph extension of dissimilarities

Description

Uses the shortest path connecting sites to estimate the distance between samples with pairwise distances greater than maxv.

Usage

```
pathdist(v, maxv = 1)
```

Arguments

v	lower-triangular distance vector, possibly as produced by <code>dist()</code> or <code>distance()</code> .
maxv	cutoff for distances: values greater or equal to this will be estimated from the minimum spanning tree.

Details

Pairwise samples with no species will have distances greater than a cutoff. A distance-weighted graph connecting these samples by way of intermediate samples with some species in common can be used to interpolate distances by adding up the path length connecting those samples. This function will fail if there are completely disconnected subsets.

Value

Returns a lower-triangular distance matrix.

Author(s)

Sarah Goslee

See Also

[dist](#), [distance](#)

Examples

```
# samples 1 and 2, and 3 and 4, have no species in common
x <- matrix(c( 1, 0, 1, 0,
0, 1, 0, 1,
1, 0, 0, 0,
0, 1, 1, 1,
1, 1, 1, 0,
1, 0, 1, 1,
0, 0, 1, 1), ncol = 4, byrow = TRUE)

# the maximum Jaccard distance is 1
# regardless of how different the samples are
x.jd <- dist(x, "binary")

# estimate the true distance between those pairs
# by following the shorted path along connected sites
pathdist(x.jd)
```

pco

*Principal coordinates analysis***Description**

Principal coordinates analysis (classical scaling).

Usage

```
pco(x, negvals = "zero", dround = 0)
```

Arguments

x	a lower-triangular dissimilarity matrix.
negvals	if = "zero" sets all negative eigenvalues to zero; if = "rm" corrects for negative eigenvalues using method 1 of Legendre and Anderson 1999.
dround	if greater than 0, attempts to correct for round-off error by rounding to that number of places.

Details

PCO (classical scaling, metric multidimensional scaling) is very similar to principal components analysis, but allows the use of any dissimilarity metric.

Value

values	eigenvalue for each component. This is a measure of the variance explained by each dimension.
vectors	eigenvectors. data frame with columns containing the scores for that dimension.

Author(s)

Sarah Goslee

See Also[princomp](#), [nmds](#)**Examples**

```
data(iris)
iris.d <- dist(iris[,1:4])
iris.pco <- pco(iris.d)

# scatterplot of the first two dimensions
plot(iris.pco$vectors[,1:2], col=as.numeric(iris$Species),
     pch=as.numeric(iris$Species), main="PC0", xlab="PC0 1", ylab="PC0 2")
```

plot.mgram

*Plot a Mantel correlogram***Description**

Plot a Mantel correlogram from an object of S3 class `mgram`, using solid symbols for significant values.

Usage

```
## S3 method for class 'mgram'
plot(x, pval = 0.05, xlab = "Distance", ylab = NULL, ...)
```

Arguments

<code>x</code>	an object of class <code>mgram</code>
<code>pval</code>	cut-off level for statistical significance.
<code>xlab</code>	x-axis label.
<code>ylab</code>	y-axis label.
<code>...</code>	optional, any additional graphics parameters.

Value

draws a plot (graphics device must be active).

Author(s)

Sarah Goslee

See Also[mgram](#)**Examples**

```
# generate a simple surface
x <- matrix(1:10, nrow=10, ncol=10, byrow=FALSE)
y <- matrix(1:10, nrow=10, ncol=10, byrow=TRUE)
z <- x + 3*y
image(z)

# analyze the pattern of z across space
space <- cbind(as.vector(x), as.vector(y))
z <- as.vector(z)
space.d <- distance(space, "eucl")
z.d <- distance(z, "eucl")
z.mgram <- mgram(z.d, space.d, nperm=0)
plot(z.mgram)

#

data(graze)
space.d <- dist(graze$siteLocation)
forest.d <- dist(graze$forestpct)

grasses <- graze[, colnames(graze) %in% c("DAGL", "LOAR10", "LOPE", "POPR")]
legumes <- graze[, colnames(graze) %in% c("LOC06", "TRPR2", "TRRE3")]

grasses.bc <- bcdist(grasses)
legumes.bc <- bcdist(legumes)

# Does the relationship of composition with distance vary for
# grasses and legumes?
par(mfrow=c(2, 1))
plot(mgram(grasses.bc, space.d, nclass=8))
plot(mgram(legumes.bc, space.d, nclass=8))
```

plot.nmds

*Plot information about NMDS ordination***Description**

Graphical display of stress and r^2 for NMDS ordination along number of dimensions.

Usage

```
## S3 method for class 'nmds'
plot(x, plot = TRUE, xlab = "Dimensions", ...)
```

Arguments

x	an object of S3 class nmds, created by nmds()
plot	optional, if TRUE a figure is produced
xlab	optional, label for x axis of graph
...	optional, other graphics parameters

Value

Produces a two-panel plot with stress and r2 for ordination by number of dimensions. Points show the mean value; lines indicate minimum and maximum.

Author(s)

Dean Urban

See Also

[nmds](#)

Examples

```
data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmds, file="ecodist/data/iris.nmds.rda")
data(iris.nmds)

# examine fit by number of dimensions
plot(iris.nmds)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmds, dims=2)
```

plot.vf

Plots fitted vectors onto an ordination diagram

Description

Add vector fitting arrows to an existing ordination plot.

Usage

```
## S3 method for class 'vf'
plot(x, pval = NULL, r = NULL, cex = 0.8, ascale = 0.9, ...)
```


Arguments

x	an object of S3 class <i>vf</i> , created by <code>vf()</code>
pval	optional, critical p-value for choosing variables to plot
r	optional, minimum Mantel r for choosing variables to plot
cex	text size
ascale	optional, proportion of plot area to use when calculating arrow length
...	optional, other graphics parameters

Value

Adds arrows to an existing ordination plot. Only arrows with a p-value less than pval are added. By default, all variables are shown.

Author(s)

Sarah Goslee

See Also

[vf](#)

Examples

```
# Example of multivariate analysis using built-in iris dataset
data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmds, file="ecodist/data/iris.nmds.rda")
data(iris.nmds)

# examine fit by number of dimensions
plot(iris.nmds)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmds, dims=2)

# fit the data to the ordination as vectors
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vf <- vf(iris.nmin, iris[,1:4], nperm=1000)
### save(iris.vf, file="ecodist/data/iris.vf.rda")
data(iris.vf)
plot(iris.nmin, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="NMDS")
plot(iris.vf)
```

pmgram

*Piecewise multivariate correlogram***Description**

This function calculates simple and partial piecewise multivariate correlograms.

Usage

```
pmgram(data, space, partial, breaks, nclass, stepsize, equiprobable = FALSE,
        resids = FALSE, nperm = 1000)
```

Arguments

data	lower-triangular dissimilarity matrix. This can be either an object of class <code>dist</code> (treated as one column) or a matrix or data frame with one or two columns, each of which is an independent lower-triangular dissimilarity in vector form.
space	lower-triangular matrix of geographic distances.
partial	optional, lower-triangular dissimilarity matrix of ancillary data.
breaks	locations of class breaks. If specified, overrides <code>nclass</code> and <code>stepsize</code> .
nclass	number of distance classes. If not specified, Sturge's rule will be used to determine an appropriate number of classes.
stepsize	width of each distance class. If not specified, <code>nclass</code> and the range of <code>space.d</code> will be used to calculate an appropriate default.
equiprobable	if <code>TRUE</code> , create <code>nclass</code> classes of equal number of distances; if <code>FALSE</code> , create <code>nclass</code> classes of equal width
resids	if <code>resids=TRUE</code> , will return the residuals for each distance class. Otherwise returns 0.
nperm	number of permutations to use. If set to 0, the permutation test will be omitted.

Details

The standard Mantel correlogram calculated by [mgram](#) tests the hypothesis that the mean compositional dissimilarity within a distance class differs from the mean of all the other distance classes combined. This function instead produces a piecewise correlogram by testing the relationship between dissimilarities within each distance class on its own, without reference to relationships across other distance classes.

This function does four different analyses: If data has 1 column and `partial` is missing, calculates a multivariate correlogram for data.

If data has 2 columns and `partial` is missing, calculates a piecewise Mantel cross-correlogram, calculating the Mantel r between the two columns for each distance class separately.

If data has 1 column and `partial` exists, calculates a partial multivariate correlogram based on residuals of `data ~ partial`.

If data has 2 columns and partial exists, does a partial Mantel cross-correlogram, calculating partial Mantel r for each distance class separately.

The Iwt statistic used for the multivariate correlograms is not the standard Mantel r . For one variable, using Euclidean distance, this metric converges on the familiar Moran autocorrelation. Like the Moran autocorrelation function, this statistic usually falls between -1 and 1, but is not bounded by those limits. Unlike the Moran function, this correlogram can be used for multivariate data, and can be extended to partial tests.

The Mantel r is used for piecewise cross-correlograms.

The comparisons in `vignette("dissimilarity", package="ecodist")` may help.

Value

Returns a object of class `mgram`, which is a list containing two objects: `mgram` is a matrix with one row for each distance class and 4 columns:

<code>lag</code>	midpoint of the distance class.
<code>ngroup</code>	number of distances in that class.
<code>piecer</code> or <code>Iwt</code>	Mantel r value or appropriate statistic (see Details).
<code>pval</code>	two-sided p-value.

`resids` is a vector of the residuals (if calculated) and can be accessed with the `residuals()` method.

Author(s)

Sarah Goslee

See Also

[mgram](#), [mantel](#), [residuals.mgram](#), [plot.mgram](#)

Examples

```
data(bump)

par(mfrow=c(1, 2))
image(bump, col=gray(seq(0, 1, length=5)))

z <- as.vector(bump)
x <- rep(1:25, times=25)
y <- rep(1:25, each=25)

X <- col(bump)
Y <- row(bump)
# calculate dissimilarities for data and space
geo.dist <- dist(cbind(as.vector(X), as.vector(Y)))
value.dist <- dist(as.vector(bump))

### pmgram() is time-consuming, so this was generated
### in advance and saved.
### set.seed(1234)
```

```

### bump.pmgram <- pmgram(value.dist, geo.dist, nperm=10000)

data(bump.pmgram)
plot(bump.pmgram)

#### Partial pmgram example

# generate a simple surface
# with complex nonlinear spatial pattern

x <- matrix(1:25, nrow=25, ncol=25, byrow=FALSE)
y <- matrix(1:25, nrow=25, ncol=25, byrow=TRUE)

# create z1 and z2 as functions of x, y
# and scale them to [0, 1]
z1 <- x + 3*y
z2 <- y - cos(x)

z1 <- (z1 - min(z1)) / (max(z1) - min(z1))
z2 <- (z2 - min(z2)) / (max(z2) - min(z2))

z12 <- (z1 + z2*2)/3

# look at patterns

layout(matrix(c(
1, 1, 2, 2,
1, 1, 2, 2,
3, 3, 4, 4,
3, 3, 5, 5), nrow=4, byrow=TRUE))

image(z1, col=gray(seq(0, 1, length=20)), zlim=c(0,1))
image(z2, col=gray(seq(0, 1, length=20)), zlim=c(0,1))
image(z12, col=gray(seq(0, 1, length=20)), zlim=c(0,1))

# analyze the pattern of z across space
z1 <- as.vector(z1)
z2 <- as.vector(z2)
z12 <- as.vector(z12)
z1.d <- dist(z1)
z2.d <- dist(z2)
z12.d <- dist(z12)

space <- cbind(as.vector(x), as.vector(y))
space.d <- dist(space)

# take partial correlogram without effects of z1
### pmgram() is time-consuming, so this was generated
### in advance and saved.
### set.seed(1234)
### z.no <- pmgram(z12.d, space.d, nperm=1000, resid=FALSE)
### save(z.no, file="ecodist/data/z.no.rda")

```

```

data(z.no)
plot(z.no)

# take partial correlogram of z12 given z1
### pmgram() is time-consuming, so this was generated
### in advance and saved.
### set.seed(1234)
### z.z1 <- pmgram(z12.d, space.d, z2.d, nperm=1000, resids=FALSE)
### save(z.z1, file="ecodist/data/z.z1.rda")
data(z.z1)
plot(z.z1)

```

relrange	<i>Relativize a compositional data matrix.</i>
----------	--

Description

Relativizes the range of each column of a data frame or matrix *x* to 0-1. If *globalmin* and/or *globalmax* are provided, those are used to scale the columns, for instance to scale a subset to match a larger sample. If they are NA, the minimum and maximum values for each column are used.

Usage

```
relrange(x, globalmin = NA, globalmax = NA)
```

Arguments

<i>x</i>	The data frame or matrix to be relativized.
<i>globalmin</i>	A value other than the population minimum to be used. Should be the same length as the number of columns of <i>x</i> .
<i>globalmax</i>	A value other than the population maximum to be used. Should be the same length as the number of columns of <i>x</i> .

Details

Relativizes the data using the minimum and maximum values. If *globalmin* and *global max* are not used, the range will be 0-1 for each variable. This can be useful for putting disparate variables to the same magnitude while keeping all non-negative values.

Value

Returns an object of the same class as *x* (matrix or data frame) with the columns rescaled.

Author(s)

Sarah Goslee

See Also[scale](#)**Examples**

```
x <- matrix(1:15, ncol = 3)

# uses min and max of the data
relrange(x)

# uses min and max determined by other knowledge of the variables
relrange(x, globalmin = c(0, 0, 0), globalmax = c(6, 10, 20))
```

residuals.mgram

*Residuals of a Mantel correlogram***Description**

Extracts residuals from an S3 object of class `mgram` (only relevant for objects created by `pmgram{}`).

Usage

```
## S3 method for class 'mgram'
residuals(object, ...)
```

Arguments

<code>object</code>	an object of class <code>mgram</code>
<code>...</code>	additional arguments

Value

vector of residuals.

Author(s)

Sarah Goslee

See Also[pmgram](#), [mgram](#)

Examples

```
#### Partial pmgram example

# generate a simple surface
# with complex nonlinear spatial pattern

x <- matrix(1:10, nrow=10, ncol=10, byrow=FALSE)
y <- matrix(1:10, nrow=10, ncol=10, byrow=TRUE)

# create z1 and z2 as functions of x, y
# and scale them to [0, 1]
z1 <- x + 3*y
z2 <- y - cos(x)

z1 <- (z1 - min(z1)) / (max(z1) - min(z1))
z2 <- (z2 - min(z2)) / (max(z2) - min(z2))

z12 <- (z1 + z2*2)/3

# analyze the pattern of z across space
z1 <- as.vector(z1)
z2 <- as.vector(z2)
z12 <- as.vector(z12)
z1.d <- dist(z1)
z2.d <- dist(z2)
z12.d <- dist(z12)

space <- cbind(as.vector(x), as.vector(y))
space.d <- dist(space)

# take partial correlogram of z12 given z1
z.z1 <- pmgram(z12.d, space.d, z2.d, nperm=0, resids=TRUE)
summary(residuals(z.z1))
```

rotate2d

Rotate a 2D ordination.

Description

Rotates a two-dimensional ordination configuration to place the direction indicated along the horizontal axis.

Usage

```
rotate2d(ord, x)
```

Arguments

ord	A matrix or data frame with two columns, or a vf object, containing the points of an ordination configuration.
x	The coordinates of a point in the ordination space.

Details

The configuration ord is rotated so that the vector defined by $c(0, 0)$, and x is along the horizontal axis. This can be useful for placing a specific variable, for instance from `vf()`, in a consistent direction across multiple ordinations. Doing so can facilitate interpretation.

Value

A rotated data frame of coordinates of the same size as ord and in the same order. If ord was produced by `vf()`, the complete vf object is returned.

Author(s)

Sarah Goslee

See Also

[vf](#), [nmds](#)

Examples

```
# Example of multivariate analysis using built-in iris dataset
data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmds, file="ecodist/data/iris.nmds.rda")
data(iris.nmds)

# examine fit by number of dimensions
plot(iris.nmds)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmds, dims=2)

# fit the data to the ordination as vectors
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vf <- vf(iris.nmin, iris[,1:4], nperm=1000)
### save(iris.vf, file="ecodist/data/iris.vf.rda")
data(iris.vf)
```



```

plot(iris.nmin, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="NMDS")
plot(iris.vf)

# rotate configuration so Sepal Width is along the horizontal axis

iris.nmin.rot <- rotate2d(iris.nmin, iris.vf[2, 1:2])
iris.vf.rot <- rotate2d(iris.vf, iris.vf[2, 1:2])

plot(iris.nmin.rot, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="NMDS")
plot(iris.vf.rot)

```

vf

Vector fitting

Description

Fits ancillary variables to an ordination configuration.

Usage

```
vf(ord, vars, nperm = 100)
```

Arguments

ord	matrix containing a 2-dimensional ordination result with axes as columns.
vars	matrix with ancillary variables as columns.
nperm	number of permutation for the significance test. If nperm = 0, the test will be omitted.

Details

Vector fitting finds the maximum correlation of the individual variables with a configuration of samples in ordination space.

Value

an object of class vf, which is a data frame with the first 2 columns containing the scores for every variable in each of the 2 dimensions of the ordination space. r is the maximum correlation of the variable with the ordination space, and pval is the result of the permutation test.

Author(s)

Sarah Goslee

References

Jongman, R.H.G., C.J.F. ter Braak and O.F.R. van Tongeren. 1995. Data analysis in community and landscape ecology. Cambridge University Press, New York.

See Also[plot.vf](#)**Examples**

```
# Example of multivariate analysis using built-in iris dataset
data(iris)
iris.d <- dist(iris[,1:4])

### nmds() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.nmds <- nmds(iris.d, nits=20, mindim=1, maxdim=4)
### save(iris.nmds, file="ecodist/data/iris.nmds.rda")
data(iris.nmds)

# examine fit by number of dimensions
plot(iris.nmds)

# choose the best two-dimensional solution to work with
iris.nmin <- min(iris.nmds, dims=2)

# fit the data to the ordination as vectors
### vf() is timeconsuming, so this was generated
### in advance and saved.
### set.seed(1234)
### iris.vf <- vf(iris.nmin, iris[,1:4], nperm=1000)
### save(iris.vf, file="ecodist/data/iris.vf.rda")
data(iris.vf)

plot(iris.nmin, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="NMDS")
plot(iris.vf)

# rotate configuration so Sepal Width is along the horizontal axis

iris.nmin.rot <- rotate2d(iris.nmin, iris.vf[2, 1:2])
iris.vf.rot <- rotate2d(iris.vf, iris.vf[2, 1:2])

plot(iris.nmin.rot, col=as.numeric(iris$Species), pch=as.numeric(iris$Species), main="NMDS")
plot(iris.vf.rot)
```

xdistance

Cross-distance between two datasets.

Description

Pairwise dissimilarity calculation between rows of one dataset and rows of another, for instance across different sampling periods for the same set of sites.

Usage

```
xdistance(x, y, method = "euclidean")
```

Arguments

<code>x</code>	A site by species or other matrix or data frame.
<code>y</code>	A a second site by species dataset, which must have at least the same columns.
<code>method</code>	This function calls distance to do the calculations, and will accept any symmetric method used there, currently: "euclidean", "bray-curtis", "manhattan", "mahalanobis" (squared Mahalanobis distance), "jaccard", "sorensen", "gower", "modgower10" (modified Gower, base 10), "modgower2" (modified Gower, base 2). Partial matching will work for selecting a method. The asymmetric "difference" method will not work for calculating cross-distances.

Details

This function will calculate rowwise dissimilarities between any pair of matrices or data frames with the same number of columns. Note that the cross-dissimilarity functions are for research purposes, and are not well-tested.

Value

A non-symmetric and possibly not square matrix of dissimilarities of class `xdist`, where `result <- xdistance(x, y)` produces a matrix with `result[a, b]` containing the dissimilarity between `x[a, ]` and `y[b, ]`.

Author(s)

Sarah Goslee

See Also

[distance](#), [xmantel](#), [xmgram](#)

Examples

```
data(graze)

### EXAMPLE 1: Square matrices

# take two subsets of sites with different dominant grass abundances
# use cut-offs that produce equal numbers of sites
dom1 <- subset(graze, POPR > 50 & DAGL < 20) # 8 sites
dom2 <- subset(graze, POPR < 50 & DAGL > 20) # 8 sites

# first two columns are site info
dom.xd <- xdistance(dom1[, -c(1,2)], dom2[, -c(1,2)], "bray")

# environmental and spatial distances; preserve rownames
forest.xd <- xdistance(dom1[, "forestpct", drop=FALSE],
```

```

    dom2[, "forestpct", drop=FALSE])
sitelocation.xd <- xdistance(dom1[, "sitelocation", drop=FALSE],
    dom2[, "sitelocation", drop=FALSE])

# permutes rows and columns of full nonsymmetric matrix
xmantel(dom.xd ~ forest.xd)
xmantel(dom.xd ~ forest.xd + sitelocation.xd)

plot(xmgram(dom.xd, sitelocation.xd))

### EXAMPLE 2: Non-square matrices

# take two subsets of sites with different dominant grass abundances
# this produces a non-square matrix

dom1 <- subset(graze, POPR > 45 & DAGL < 20) # 13 sites
dom2 <- subset(graze, POPR < 45 & DAGL > 20) # 8 sites

# first two columns are site info
dom.xd <- xdistance(dom1[, -c(1,2)], dom2[, -c(1,2)], "bray")

# environmental and spatial distances; preserve rownames
forest.xd <- xdistance(dom1[, "forestpct", drop=FALSE],
    dom2[, "forestpct", drop=FALSE])
sitelocation.xd <- xdistance(dom1[, "sitelocation", drop=FALSE],
    dom2[, "sitelocation", drop=FALSE])

# permutes rows and columns of full nonsymmetric matrix
xmantel(dom.xd ~ forest.xd, dims=c(13, 8))
xmantel(dom.xd ~ forest.xd + sitelocation.xd, dims=c(13, 8))

plot(xmgram(dom.xd, sitelocation.xd))

```

xmantel

Cross-Mantel test

Description

Simple and partial cross-Mantel tests, with options for ranked data and permutation tests.

Usage

```

xmantel(formula = formula(data), data, dims = NA,
    nperm = 1000, mrank = FALSE)

```

Arguments

formula	formula describing the test to be conducted. For this test, $y \sim x$ will perform a simple Mantel test, while $y \sim x + z1 + z2 + z3$ will do a partial Mantel test of
---------	--

	the relationship between x and y given z1, z2, z3. All variables should be either non-symmetric square cross-dissimilarity matrices of class xdist, or vector forms thereof.
data	an optional dataframe containing the variables in the model as columns of dissimilarities. By default the variables are taken from the current environment.
dims	if the dissimilarity matrices are not square, the dimensions must be provided as c(nrow, ncol)
nperm	number of permutations to use. If set to 0, the permutation test will be omitted.
mrank	if this is set to FALSE (the default option), Pearson correlations will be used. If set to TRUE, the Spearman correlation (correlation ranked distances) will be used.

Details

If only one independent variable is given, the simple Mantel r (r_{12}) is calculated. If more than one independent variable is given, the partial Mantel r ($r_{y|x_1 \dots}$) is calculated by permuting one of the original dissimilarity matrices. Note that the cross-dissimilarity functions are for research purposes, and are not well-tested.

Value

mantelr	Mantel coefficient.
pval1	one-tailed p-value (null hypothesis: $r \leq 0$).
pval2	one-tailed p-value (null hypothesis: $r \geq 0$).
pval3	two-tailed p-value (null hypothesis: $r = 0$).

Author(s)

Sarah Goslee

See Also

[xdistance](#), [xmgram](#)

Examples

```
data(graze)

### EXAMPLE 1: Square matrices

# take two subsets of sites with different dominant grass abundances
# use cut-offs that produce equal numbers of sites
dom1 <- subset(graze, POPR > 50 & DAGL < 20) # 8 sites
dom2 <- subset(graze, POPR < 50 & DAGL > 20) # 8 sites

# first two columns are site info
dom.xd <- xdistance(dom1[, -c(1,2)], dom2[, -c(1,2)], "bray")
```

```

# environmental and spatial distances; preserve rownames
forest.xd <- xdistance(dom1[, "forestpct", drop=FALSE],
  dom2[, "forestpct", drop=FALSE])
sitelocation.xd <- xdistance(dom1[, "sitelocation", drop=FALSE],
  dom2[, "sitelocation", drop=FALSE])

# permutes rows and columns of full nonsymmetric matrix
xmantel(dom.xd ~ forest.xd)
xmantel(dom.xd ~ forest.xd + sitelocation.xd)

plot(xmgram(dom.xd, sitelocation.xd))

### EXAMPLE 2: Non-square matrices

# take two subsets of sites with different dominant grass abundances
# this produces a non-square matrix

dom1 <- subset(graze, POPR > 45 & DAGL < 20) # 13 sites
dom2 <- subset(graze, POPR < 45 & DAGL > 20) # 8 sites

# first two columns are site info
dom.xd <- xdistance(dom1[, -c(1,2)], dom2[, -c(1,2)], "bray")

# environmental and spatial distances; preserve rownames
forest.xd <- xdistance(dom1[, "forestpct", drop=FALSE],
  dom2[, "forestpct", drop=FALSE])
sitelocation.xd <- xdistance(dom1[, "sitelocation", drop=FALSE],
  dom2[, "sitelocation", drop=FALSE])

# permutes rows and columns of full nonsymmetric matrix
xmantel(dom.xd ~ forest.xd, dims=c(13, 8))
xmantel(dom.xd ~ forest.xd + sitelocation.xd, dims=c(13, 8))

plot(xmgram(dom.xd, sitelocation.xd))

```

xmgram

Cross-Mantel correlogram

Description

Calculates simple Mantel correlograms from cross-distance matrices.

Usage

```

xmgram(species.xd, space.xd, breaks, nclass, stepsize, equiprobable = FALSE, nperm = 1000,
  mrank = FALSE, alternative = "two.sided", trace = FALSE)

```

Arguments

species.xd	non-symmetric square cross-distance matrix.
space.xd	non-symmetric square matrix of geographic distances.
breaks	locations of class breaks. If specified, overrides nclass and stepsize.
nclass	number of distance classes. If not specified, Sturge's rule will be used to determine an appropriate number of classes.
stepsize	width of each distance class. If not specified, nclass and the range of space.d will be used to calculate an appropriate default.
equiprobable	if TRUE, create nclass classes of equal number of distances; if FALSE, create nclass classes of equal width
nperm	number of permutations to use. If set to 0, the permutation test will be omitted.
mrnk	if this is set to FALSE (the default option), Pearson correlations will be used. If set to TRUE, the Spearman correlation (correlation ranked distances) will be used.
alternative	default is "two.sided", and returns p-values for $H_0: r_M = 0$. The alternative is "one.sided", which returns p-values for $H_0: r_M \leq 0$.
trace	if TRUE, returns progress indicators.

Details

This function calculates cross-Mantel correlograms. The Mantel correlogram is essentially a multivariate autocorrelation function. The Mantel r represents the dissimilarity in variable composition (often species composition) at a particular lag distance. Note that the cross-dissimilarity functions are for research purposes, and are not well-tested.

Value

Returns an object of class `mgram`, which is a list with two elements. `mgram` is a matrix with one row for each distance class and 6 columns:

lag	midpoint of the distance class.
ngroup	number of distances in that class.
mantelr	Mantel r value.
pval	p-value for the test chosen.

resids is NA for objects calculated by `mgram()`.

Author(s)

Sarah Goslee

References

Legendre, P. and M. Fortin. 1989. Spatial pattern and ecological analysis. *Vegetatio* 80:107-138.

See Also

[xdistance](#), [xmantel](#), [plot.mgram](#)

Examples

```
# Need to develop a cross-dissimilarity example
data(graze)

### EXAMPLE 1: Square matrices

# take two subsets of sites with different dominant grass abundances
# use cut-offs that produce equal numbers of sites
dom1 <- subset(graze, POPR > 50 & DAGL < 20) # 8 sites
dom2 <- subset(graze, POPR < 50 & DAGL > 20) # 8 sites

# first two columns are site info
dom.xd <- xdistance(dom1[, -c(1,2)], dom2[, -c(1,2)], "bray")

# environmental and spatial distances; preserve rownames
forest.xd <- xdistance(dom1[, "forestpct", drop=FALSE],
  dom2[, "forestpct", drop=FALSE])
sitelocation.xd <- xdistance(dom1[, "sitelocation", drop=FALSE],
  dom2[, "sitelocation", drop=FALSE])

# permutes rows and columns of full nonsymmetric matrix
xmante1(dom.xd ~ forest.xd)
xmante1(dom.xd ~ forest.xd + sitelocation.xd)

plot(xmgram(dom.xd, sitelocation.xd))

### EXAMPLE 2: Non-square matrices

# take two subsets of sites with different dominant grass abundances
# this produces a non-square matrix

dom1 <- subset(graze, POPR > 45 & DAGL < 20) # 13 sites
dom2 <- subset(graze, POPR < 45 & DAGL > 20) # 8 sites

# first two columns are site info
dom.xd <- xdistance(dom1[, -c(1,2)], dom2[, -c(1,2)], "bray")

# environmental and spatial distances; preserve rownames
forest.xd <- xdistance(dom1[, "forestpct", drop=FALSE],
  dom2[, "forestpct", drop=FALSE])
sitelocation.xd <- xdistance(dom1[, "sitelocation", drop=FALSE],
  dom2[, "sitelocation", drop=FALSE])

# permutes rows and columns of full nonsymmetric matrix
xmante1(dom.xd ~ forest.xd, dims=c(13, 8))
xmante1(dom.xd ~ forest.xd + sitelocation.xd, dims=c(13, 8))
```



```
plot(xmgram(dom.xd, sitelocation.xd))
```

z.no

Example for pmgram

Description

An object of class mgram for use in the example for [pmgram](#). Many of the functions in ecodist take a long time to run, so prepared examples have been included.

Usage

```
data(z.no)
```

Format

See [pmgram](#) for current format specification.

Author(s)

Sarah Goslee

See Also

[pmgram](#), [z.z1](#),

Examples

```
#### Partial pmgram example

# generate a simple surface
# with complex nonlinear spatial pattern

x <- matrix(1:25, nrow=25, ncol=25, byrow=FALSE)
y <- matrix(1:25, nrow=25, ncol=25, byrow=TRUE)

# create z1 and z2 as functions of x, y
# and scale them to [0, 1]
z1 <- x + 3*y
z2 <- y - cos(x)

z1 <- (z1 - min(z1)) / (max(z1) - min(z1))
z2 <- (z2 - min(z2)) / (max(z2) - min(z2))

z12 <- (z1 + z2*2)/3

# look at patterns

layout(matrix(c(
1, 1, 2, 2,
```

```

1, 1, 2, 2,
3, 3, 4, 4,
3, 3, 5, 5), nrow=4, byrow=TRUE))

image(z1, col=gray(seq(0, 1, length=20)), zlim=c(0,1))
image(z2, col=gray(seq(0, 1, length=20)), zlim=c(0,1))
image(z12, col=gray(seq(0, 1, length=20)), zlim=c(0,1))

# analyze the pattern of z across space
z1 <- as.vector(z1)
z2 <- as.vector(z2)
z12 <- as.vector(z12)
z1.d <- dist(z1)
z2.d <- dist(z2)
z12.d <- dist(z12)

space <- cbind(as.vector(x), as.vector(y))
space.d <- dist(space)

# take partial correlogram without effects of z1
### pgram() is time-consuming, so this was generated
### in advance and saved.
### set.seed(1234)
### z.no <- pmgram(z12.d, space.d, nperm=1000, resid=FALSE)
### save(z.no, file="ecodist/data/z.no.rda")
plot(z.no)

# take partial correlogram of z12 given z1
### pgram() is time-consuming, so this was generated
### in advance and saved.
### set.seed(1234)
### z.z1 <- pmgram(z12.d, space.d, z2.d, nperm=1000, resid=FALSE)
### save(z.z1, file="ecodist/data/z.z1.rda")
plot(z.z1)

```

z.z1

Example for pmgram

Description

An object of class `mgram` for use in the example for `pmgram`. Many of the functions in `ecodist` take a long time to run, so prepared examples have been included.

Usage

```
data(z.z1)
```

Format

See `pmgram` for current format specification.

Author(s)

Sarah Goslee

See Also

[pmgram](#), [z.no](#),

Examples

```
#### Partial pmgram example

# generate a simple surface
# with complex nonlinear spatial pattern

x <- matrix(1:25, nrow=25, ncol=25, byrow=FALSE)
y <- matrix(1:25, nrow=25, ncol=25, byrow=TRUE)

# create z1 and z2 as functions of x, y
# and scale them to [0, 1]
z1 <- x + 3*y
z2 <- y - cos(x)

z1 <- (z1 - min(z1)) / (max(z1) - min(z1))
z2 <- (z2 - min(z2)) / (max(z2) - min(z2))

z12 <- (z1 + z2*2)/3

# look at patterns

layout(matrix(c(
  1, 1, 2, 2,
  1, 1, 2, 2,
  3, 3, 4, 4,
  3, 3, 5, 5), nrow=4, byrow=TRUE))

image(z1, col=gray(seq(0, 1, length=20)), zlim=c(0,1))
image(z2, col=gray(seq(0, 1, length=20)), zlim=c(0,1))
image(z12, col=gray(seq(0, 1, length=20)), zlim=c(0,1))

# analyze the pattern of z across space
z1 <- as.vector(z1)
z2 <- as.vector(z2)
z12 <- as.vector(z12)
z1.d <- dist(z1)
z2.d <- dist(z2)
z12.d <- dist(z12)

space <- cbind(as.vector(x), as.vector(y))
space.d <- dist(space)

# take partial correlogram without effects of z1
#### pgram() is time-consuming, so this was generated
```

```
### in advance and saved.
### set.seed(1234)
### z.no <- pmgram(z12.d, space.d, nperm=1000, resids=FALSE)
### save(z.no, file="ecodist/data/z.no.rda")
plot(z.no)

# take partial correlogram of z12 given z1
### pgram() is time-consuming, so this was generated
### in advance and saved.
### set.seed(1234)
### z.z1 <- pmgram(z12.d, space.d, z2.d, nperm=1000, resids=FALSE)
### save(z.z1, file="ecodist/data/z.z1.rda")
plot(z.z1)
```

Index

- * **datasets**
 - bump, 7
 - bump.pmgram, 8
 - graze, 17
 - iris.fit, 19
 - iris.nmbs, 20
 - iris.vf, 21
 - iris.vfrot, 22
 - z.no, 57
 - z.z1, 58
- * **distribution**
 - corgen, 10
- * **hplot**
 - plot.mgram, 38
 - plot.nmbs, 39
 - plot.vf, 40
- * **manip**
 - crosstab, 11
 - dim.dist, 13
 - fixdmat, 15
 - full, 16
 - lower, 23
- * **multivariate**
 - addord, 4
 - bcdist, 6
 - cor2m, 9
 - crosstab, 11
 - dim.dist, 13
 - distance, 13
 - fixdmat, 15
 - full, 16
 - lower, 23
 - mantel, 25
 - mgram, 27
 - mgroup, 29
 - min.nmbs, 30
 - MRM, 32
 - nmbs, 33
 - pathdist, 36
 - pco, 37
 - plot.mgram, 38
 - plot.nmbs, 39
 - plot.vf, 40
 - pmgram, 42
 - relrange, 45
 - residuals.mgram, 46
 - rotate2d, 47
 - vf, 49
 - xdistance, 50
 - xmantel, 52
 - xmgram, 54
- * **package**
 - ecodist-package, 2
- addord, 4, 19, 34
- bcdist, 6, 14
- bump, 7, 8
- bump.pmgram, 8, 8
- cor2m, 3, 9
- corgen, 10
- crosstab, 3, 11
- dim.dist, 13
- dist, 7, 14, 36
- distance, 6, 7, 13, 36, 51
- ecodist (ecodist-package), 2
- ecodist-package, 2
- fixdmat, 15, 16, 24
- full, 15, 16, 24
- graze, 17
- iris.fit, 19
- iris.nmbs, 20
- iris.vf, 21
- iris.vfrot, 22

lower, [15](#), [16](#), [23](#)

mantel, [3](#), [25](#), [28](#), [30](#), [33](#), [43](#)
mgram, [26](#), [27](#), [39](#), [42](#), [43](#), [46](#)
mggroup, [26](#), [29](#)
min.nmids, [30](#), [34](#)
MRM, [32](#)

nmids, [3](#), [19–22](#), [31](#), [33](#), [38](#), [40](#), [48](#)
nmids.min (min.nmids), [30](#)

pathdist, [36](#)
pco, [37](#)
plot.mgram, [28](#), [38](#), [43](#), [56](#)
plot.nmids, [34](#), [39](#)
plot.vf, [40](#), [50](#)
pmgram, [8](#), [28](#), [42](#), [46](#), [57–59](#)
princomp, [38](#)

relnrange, [45](#)
residuals.mgram, [43](#), [46](#)
rotate2d, [47](#)

scale, [46](#)

vf, [21](#), [22](#), [34](#), [41](#), [48](#), [49](#)

xdistance, [50](#), [53](#), [56](#)
xmantel, [3](#), [51](#), [52](#), [56](#)
xmgram, [51](#), [53](#), [54](#)

z.no, [57](#), [59](#)
z.z1, [57](#), [58](#)