

Package ‘variosig’

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Title Testing Spatial Dependence Using Empirical Variogram

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Description Applying Monte Carlo permutation to generate pointwise variogram envelope and checking for spatial dependence at different scales using permutation test. Empirical Brown's method and Fisher's method are used to compute overall p-value for hypothesis test.

License GPL (>= 3)

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variosig-package

Testing Spatial Dependence Using Empirical Variogram

Description

Applying Monte Carlo permutation to generate pointwise variogram envelope and checking for spatial dependence at different scales using permutation test. Empirical Brown's method and Fisher's method are used to compute overall p-value for hypothesis test.

Details

Package: variosig
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Author(s)

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envelope

Generate Pointwise Variogram Envelope

Description

Apply Monte Carlo permutation on the data values over different locations, and compute the variogram estimates for each permutation. The pointwise variogram envelope is taken based on quantiles of variogram estimates at each distance binning.

Usage

```
## S3 method for class 'gstatVariogram'
envelope(vario, data, locations = coordinates(data),
  formula = NULL, cluster = FALSE, n.cluster = NULL,
  nsim = 999, conf.level = 0.95, save.sim = FALSE, ...)

## S3 method for class 'variogram'
envelope(vario, data, locations = data$coords,
  trend = NULL, cluster = FALSE, n.cluster = NULL,
  nsim = 999, conf.level = 0.95, save.sim = FALSE, ...)
```

Arguments

<code>vario</code>	variogram of class <code>gstatVariogram</code> from the <code>gstat</code> package or variogram from the <code>geoR</code> package.
<code>data</code>	an object of class <code>SpatialPointsDataFrame</code> if <code>vario</code> is from <code>geoR</code> or class <code>geodata</code> if <code>vario</code> is from <code>gstat</code> .
<code>locations</code>	matrix. Contains x-coordinates in the first column and y-coordinates in the second column.
<code>formula</code>	only works with <code>gstat</code> package, a formula defining the response variable and possible covariates.
<code>trend</code>	only works with <code>geoR</code> package, defining the response variable and possible covariates. See documentation of trend.spatial for further details.
<code>cluster</code>	logical. If <code>TRUE</code> , clustering-based permutation is used. See Details.
<code>n.cluster</code>	integer. The number of clusters used in the permutation. Only used when <code>cluster = TRUE</code> .
<code>nsim</code>	integer. The number of permutations conducted to compute the envelope. The default is 999.
<code>conf.level</code>	confidence level of the envelope. The default is 0.95.
<code>save.sim</code>	logical. If <code>TRUE</code> , save all the permuted data.
<code>...</code>	any other arguments that will be passed to variogram computation using either variogram from <code>gstat</code> package or variog from <code>geoR</code> package.

Details

There are two possible permutation methods implemented. If `cluster = FALSE`, complete spatial randomness is assumed and values are permuted over all locations. If `cluster = TRUE`, spatial dependence at small scales is assumed and values are permuted only within clusters which are determined using `kmeans` clustering over spatial locations. When the interest is about the existence of spatial dependence at small scales, `cluster = TRUE` is preferred to achieve a higher statistical power.

Value

A list with the following elements:

<code>data</code>	contains a list of all permuted data, only exists if <code>save.sim=TRUE</code>
<code>variogram</code>	the original variogram estimates and estimates from each of the permutations
<code>upper</code>	upper quantile of the variogram estimates according to the confidence level
<code>lower</code>	lower quantile of the variogram estimates according to the confidence level
<code>data.values</code>	the values used for variogram estimation, namely the residuals after removing covariates' effect
<code>variogram0</code>	the original variogram supplied via <code>vario</code> argument

Author(s)

Craig Wang, Reinhard Furrer

References

Diggle, P.J., Ribeiro, P.J. (2007), *Model-Based Geostatistics*, Springer Series in Statistics. Springer.

Wang, C., Furrer, R. (2018) Monte Carlo Permutation Tests for Assessing Spatial Dependence at Difference Scales. *Nonparametric Statistics*. (Submitted)

See Also

[envplot](#) to plot an empirical variogram based on the data and its envelope

Examples

```
## Not run:
library(sp)
data(meuse)

## for gstat variogram

library(gstat)
data(meuse)
coordinates(meuse) = ~x+y
vario0 <- gstat::variogram(log(zinc)~1, meuse)
varioEnv <- envelope(vario0, data = meuse,
  formula = log(zinc)~1, nsim = 499, cluster = TRUE, n.cluster = 10)

## for geoR variog

library(geoR)
data(meuse)
meuse <- as.geodata(meuse, coords.col = 1:2, data.col = 6, covar.col = 3:5)
meuse$data <- log(meuse$data)
vario0 <- variog(meuse,max.dist=1500)
varioEnv <- envelope(vario0, data = meuse,
  trend = trend.spatial(~lead, meuse), nsim = 499)

## End(Not run)
```

envplot

Plot Empirical Variogram and its Pointwise Envelope

Description

Plot empirical variogram and its pointwise variogram envelope.

Usage

```
envplot(envlist, shade = TRUE, shade.color = "lightgrey",
  show.variance = FALSE, xlim = NULL, ylim = NULL,
  main = NULL, xlab = "Distance", ylab = "Semivariance")
```

Arguments

envlist	output from envelope function.
shade	logical. If TRUE, the envelope is shaded.
shade.color	string. Color of the envelope if it is shaded.
show.variance	logical. Plot horizontal lines showing the sample variance and its confidence interval of residuals ignoring spatial information.
xlim, ylim	x-axis and y-axis range. If NULL, default values are chosen.
main	string. Title of the plot.
xlab, ylab	string. Labels for x- and y-axis.

Value

Nothing is returned, generates a plot.

Author(s)

Craig Wang

See Also

[envelope](#) to use Monte Carlo permutations for generating variogram envelope.

Examples

```
## Not run:
library(sp)
data(meuse)
coordinates(meuse) = ~x+y
vario0 <- gstat::variogram(log(zinc)~1, meuse)
varioEnv <- envelope(vario0, data = meuse, formula = log(zinc)~1, nsim = 499)
envplot(varioEnv)

## End(Not run)
```

envsig	<i>Determine Significance of Spatial Dependence Using Pointwise Variogram Envelope</i>
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Description

Determine the significance of spatial dependence at different scales using pointwise variogram envelope based on permutation test.

Usage

```
envsig(envlist, index = NULL, method = c("eb", "fisher", "min"))
```

Arguments

envlist	output from envelope function.
index	integer. Indicating the index which the permutation test for spatial dependence is performed up to. For example, index = 2 indicates only the first two variogram estimates are considered in the hypothesis test, i.e. null hypothesis is there is no spatial dependence at small scales. If NULL, all variogram estimates are considered, which corresponds to the null hypothesis of no overall spatial dependence.
method	string. One of p-value combination methods.

Details

The default and preferred method for computing overall p-value is "eb" (empirical Brown's method), which has good power and close to nominal type I error rate. "fisher" (Fisher's method assumes independent pointwise p-values and requires higher sample size to achieve good power. "min" has the highest power but also much higher type I error rate.

Value

A list contains:

p.pointwise	Adjusted pointwise p-values.
p.overall	Overall p-value of the permutation test.

Author(s)

Craig Wang

References

- Walker, D. D., J. C. Loftis, and J. P. W. Mielke (1997). Permutation methods for determining the significance of spatial dependence. *Mathematical Geology* 29(8), 1011–1024.
- Fisher R. A. (1932). *Statistical methods for research workers*, 4th ed. Oliver & Boyd.
- Poole, W., D. L. Gibbs, I. Shmulevich, B. Bernard, and T. A. Knijnenburg (2016). Combining dependent P-values with an empirical adaptation of Brown's method. *Bioinformatics* 32(17), 430–436.
- Wang, C., Furrer, R. (2018) Monte Carlo Permutation Tests for Assessing Spatial Dependence at Difference Scales. *Nonparametric Statistics*. (Submitted)

See Also

[envelope](#) to use Monte Carlo permutations for generating variogram envelope.

Examples

```
## Not run:
library(sp)
data(meuse)
coordinates(meuse) = ~x+y
vario0 <- gstat::variogram(log(zinc)~1, meuse)
varioEnv <- envelope(vario0, data = meuse, formula = log(zinc)~1,
  nsim = 500, cluster = TRUE, n.cluster = 10)
envplot(varioEnv)
envsig(varioEnv, index = 2, method = "eb")

## End(Not run)
```

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