Package 'spANOVA'

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Type Package

Title Analysis of Field Trials with Geostatistics & Spatial AR Models

Version 0.99.4

Description Perform analysis of variance when the experimental units are spatially correlated. There are two methods to deal with spatial dependence: Spatial autoregressive models (see Rossoni, D. F., & Lima, R. R. (2019) <doi:10.28951/rbb.v37i2.388>) and geostatistics (see Pontes, J. M., & Oliveira, M. S. D. (2004) <doi:10.1590/S1413-70542004000100018>). For both methods, there are three multicomparison procedure available: Tukey, multivariate T, and Scott-Knott.

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Imports MASS, Matrix, ScottKnott, car, gtools, multcomp, multcompView, mvtnorm, DT, shinyBS, xtable, shinythemes, rmarkdown, knitr, spdep, ape, spatialreg, shinycssloaders

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aovGeo *Analysis of variance using a geostatistical model to handle spatial dependence*

Description

Fit an analysis of variance model using geostatistics for modeling the spatial dependence among the observations.

Usage

```
aovGeo(model, cutoff = 0.5, tol = 1e-3)

## S3 method for class 'spVariofitRCBD'
aovGeo(model, cutoff = 0.5, tol = 0.001)
```

Arguments

model	an object of class spVariofit.
cutoff	a value in (0,1] interval representing the percentage of the maximum distance adopted to estimate the variogram in the algorithm suggested by Pontes & Oliveira (2004). See 'Details'.
tol	the desired accuracy.

Details

Three assumptions are made about the error in the analysis of variance (ANOVA):

1. The errors come from a normal distribution.

2. The errors have the same variance.

3. The errors are uncorrelated.

However, in many experiments, especially field trials, there is a type of correlation generated by the sample locations known as spatial autocorrelation, and this condition violates the independence assumption.

In that way, we need to regard this spatial autocorrelation and include it in the final model. It could be done adopting a geostatistical model to characterize the spatial variability among the observations directly in the covariance matrix.

The geostatistical modeling is based on the residuals of the standard model (where the errors are assumed to be independent, uncorrelated and having a normal distribution with mean 0 and constant variance). The basic idea is using them to estimate the residuals of the spatially autocorrelated model in order to fit a theoretical geostatistic model to build the covariance matrix. As Pointed by Pontes & Oliveira (2004), this task can be done using the following algorithm

1 - Extract the residuals from the standard model

2 - Fit a variogram based on residuals obtained in step 1.

3 - Fit a theoretical model to describe the spatial dependence observed in the variogram.

4 - On basis in the theoretical model fitted in step 3 and its parameter estimates, create the covariance matrix.

5 - Estimate the residuals using the covariance matrix obtained in step 4 and use them to create a variogram.

6 - Fit a theoretical model to the residual variogram obtained in step 5 and use its parameters estimates to build a new covariance matrix.

7 - Repeat 5 to 6 until convergence.

Step 1 is implemented in spVariog. Steps 2 and 3 are implemented in spVariofit. aovGeo implements steps 4 to 7 and needs a cutoff argument to define the maximum distance in the computation of the residual variogram described in step 6

In presence of spatial trend, the model is modified in order to include the effect of the spatial coordinates.

Value

aovGeo returns an object of class "GEOanova". The functions summary and anova are used to obtain and print a summary and analysis of variance table of the results. An object of class "GEOanova" is a list containing the following components:

DF	degrees of freedom of coordinates (in presence of spatial trend), treatments, block (if RCBD), residual and total.
SS	sum of squares of coordinates (in presence of spatial trend), treatments, block (if RCBD), residual and total.
MS	mean of squares of coordinates (in presence of spatial trend), treatments, block (if RCBD), residual and total.
Fc	F statistic calculated for coordinates (in presence of spatial trend), treatment and block (if RCBD).
p.value	p-value associated to F statistic for coordinates (in presence of spatial trend), treatment and block (if RCBD).
residuals	residuals extracted from the model
params	variogram parameter estimates from Pontes & Oliveira (2004) algorithm.
type	type of trend in the data. It can be "trend" or "cte".

model	geostatistical model used to describe the spatial dependence.
data	data set used in the analysis.
des.mat	design matrix.
beta	parameter estimates of the linear model taking into account the spatial dependence.
n	number of observations.
vcov	covariance matrix built taking into account the spatial dependence.
design	character string indicating the name of the experimental design.

References

Nogueira, C. H., de Liima, R. R., & de Oliveira, M. S. (2013). Aprimoramento da Análise de Variância: A Influência da Proximidade Espacial. Rev. Bras. Biom, 31(3), 408-422.

Nogueira, C.H., et al. (2015). Modelagem espacial na análise de um plantio experimental de candeia. Rev. Bras. Biom., São Paulo, v.33, n.1, p.14-29.

Pontes, J. M., & de Oliveira, M. S. (2004). An alternative proposal to the analysis of field experiments using geostatistics. Ciência e Agrotecnologia, 28(1), 135-141.

Gotway, C. A., & Cressie, N. A. (1990). A spatial analysis of variance applied to soil water infiltration. Water Resources Research, 26(11), 2695-703.

Examples

```
data("crd_simulated")

#Geodata object
geodados <- as.geodata(crd_simulated, coords.col = 1:2, data.col = 3,
                       covar.col = 4)
h_max <- summary(geodados)[[3]][[2]]
dist <- 0.6*h_max

# Computing the variogram
variograma <- spVariog(geodata = geodados,
                       trend = "cte", max.dist = dist, design = "crd",
                       scale = FALSE)

plot(variograma, ylab = "Semivariance", xlab = "Distance")

# Gaussian Model
ols <- spVariofit(variograma, cov.model = "gaussian", weights = "equal",
                  max.dist = dist)

lines(ols, col = 1)

# Compute the model and get the analysis of variance table
mod <- aovGeo(ols, cutoff = 0.6)
anova(mod)
```

aovSar.crd	*Using a SAR model to handle spatial dependence in a Completely Randomized Design*

Description

Fit a completely randomized design when the experimental units have some degree of spatial dependence using a Spatial Lag Model (SAR).

Usage

```
aovSar.crd(resp, treat, coord, seq.radius)
```

Arguments

resp	Numeric or complex vector containing the values of the response variable.
treat	Numeric or complex vector containing the treatment applied to each experimental unit.
coord	Matrix of point coordinates.
seq.radius	Complex vector containing a radii sequence used to set the neighborhood pattern. The default sequence has ten numbers from 0 to half of the maximum distance between the samples, if no sample is found in this interval the sequence upper limit is increased by 10% and so on.

Details

Three assumptions are made about the error in the analysis of variance (ANOVA):

1. the errors are normally distributed and, on average, zero;

2. the errors all have the same variance (they are homoscedastic), and

3. the errors are unrelated to each other (they are independent across observations).

When these assumptions are not satisfied, data transformations in the response variable are often used to circumvent this problem. For example, in absence of normality, the Box-Cox transformation can be used.

However, in many experiments, especially field trials, there is a type of correlation generated by the sample locations known as spatial correlation, and this condition violates the independence assumption. errors are spatially correlated, by using a data transformation discussed in Long (1996)

$$Y_{adj} = Y - (\hat{\rho}WY - \hat{\rho}\beta_0),$$

where $\hat{\rho}$ denotes the autoregressive spatial parameter of the SAR model estimated by lagsarlm, β_0 is the overall mean and W is a spatial neighborhood matrix which neighbors are defined as the samples located within a radius, this radius is specified as a sequence in seq.radius. For each radius in seq.radius the model is computed as well its AIC, then the radius chosen is the one that minimizes AIC.

The aim of this transformation is converting autocorrelated observations into non-correlated observations in order to apply the analysis of variance and obtain suitable inferences.

Value

aovSar.crd returns an object of [class](#) "SARanova". The functions [summary](#) and anova are used to obtain and print a summary and analysis of variance table of the results. An object of class "SARanova" is a list containing the following components:

DF	degrees of freedom of rho, treatments, residual and total.
SS	sum of squares of rho, treatments and residual.
MS	mean square of rho, treatments and residual.
Fc	F statistic calculated for treatment.
residuals	residuals of the adjusted model.
p.value	p-value associated to F statistic for treatment.
rho	the autoregressive parameter.
Par	data.frame with the radius tested and its AIC.
y_orig	vector of response.
y_ajus	vector of adjusted response.
treat	vector of treatment applied to each experimental unit.
modelAdj	model of class [aov](#) using the adjusted response.
modelstd	data frame containing the ANOVA table using non-adjusted response.
namey	response variable name.
namex	treatment variable name.

References

Long, D.S., 1996. Spatial statistics for analysis of variance of agronomic field trials. In: Arlinghaus, S.L. (Ed.), Practical Handbook of Spatial Statistics. CRC Press, Boca Raton, FL, pp. 251–278.

Rossoni, D. F.; Lima, R. R. . Autoregressive analysis of variance for experiments with spatial dependence between plots: a simulation study. Revista Brasileira de Biometria, 2019.

Scolforo, Henrique Ferraço, et al. "Autoregressive spatial analysis and individual tree modeling as strategies for the management of Eremanthus erythropappus." Journal of forestry research 27.3 (2016): 595-603.

Examples

```
data("crd_simulated")
resp <- crd_simulated$y
treat <- crd_simulated$trat
coord <- cbind(crd_simulated$coordX, crd_simulated$coordY)
cv <- aovSar.crd(resp, treat, coord)

#Summary for class SARanova
summary(cv)

#Anova for class SARanova
anova(cv)
```

---

aovSar.gen   *Using a SAR model to handle spatial dependence in an aov model.*

Description

Fit a completely randomized design when the experimental units have some degree of spatial dependence using a Spatial Lag Model (SAR).

Usage

```
aovSar.gen(formula, coord, seq.radius, data = NULL)
```

Arguments

formula	A formula specifying the model.
coord	A matrix or data.frame of point coordinates.
seq.radius	A complex vector containing a radii sequence used to set the neighborhood pattern. The default sequence has ten numbers from 0 to half of the maximum distance between the samples.
data	A data frame in which the variables specified in the formula will be found.

Details

Three assumptions are made about the error in the analysis of variance (ANOVA):

1. the errors are normally distributed and, on average, zero;

2. the errors all have the same variance (they are homoscedastic), and

3. the errors are unrelated to each other (they are independent across observations).

When these assumptions are not satisfied, data transformations in the response variable are often used to circumvent this problem. For example, in absence of normality, the Box-Cox transformation can be used.

However, in many experiments, especially field trials, there is a type of correlation generated by the sample locations known as spatial correlation, and this condition violates the independence assumption. In this setting, this function provides an alternative for using ANOVA when the errors are spatially correlated, by using a data transformation discussed in Long (1996)

$$Y_{adj} = Y - (\hat{\rho}WY - \hat{\rho}\beta_0),$$

where $\hat{\rho}$ denotes the autoregressive spatial parameter of the SAR model estimated by lagsarlm, β_0 is the overall mean and W is a spatial neighborhood matrix which neighbors are defined as the samples located within a radius, this radius is specified as a sequence in seq.radius. For each radius in seq.radius the model is computed as well its AIC, then the radius chosen is the one that minimizes AIC.

The aim of this transformation is converting autocorrelated observations into non-correlated observations in order to apply the analysis of variance and obtain suitable inferences.

Value

aovSar.gen returns an object of [class](#) "SARaov". The functions summary and anova are used to obtain and print a summary and analysis of variance table of the results. An object of class "SARaov" is a list containing the following components:

DF	degrees of freedom of rho, treatments, residual and total.
SS	sum of squares of residuals and total.
residuals	residuals of the adjusted model.
MS	mean square of residuals and total.
rho	the autoregressive parameter.
Par	data.frame with the radius tested and its AIC.
modelAdj	model of class [aov](#) using the adjusted response.
modelstd	data frame containing the ANOVA table using non-adjusted response.
namey	response variable name.

References

Long, D. S. "Spatial statistics for analysis of variance of agronomic field trials." Practical handbook of spatial statistics. CRC Press, Boca Raton, FL (1996): 251-278.

Rossoni, D. F.; Lima, R. R. . Autoregressive analysis of variance for experiments with spatial dependence between plots: a simulation study. Revista Brasileira de Biometria, 2019

Scolforo, Henrique Ferraço, et al. "Autoregressive spatial analysis and individual tree modeling as strategies for the management of Eremanthus erythropappus." Journal of forestry research 27.3 (2016): 595-603.

Examples

```
data("crd_simulated")
coord <- cbind(crd_simulated$coordX, crd_simulated$coordY)
cv <- aovSar.gen(y ~ trat, coord, data = crd_simulated)
cv

#Summary for class SARanova
summary(cv)

#Anova for class SARanova
anova(cv)
```

---

aovSar.rcbd   *Using a SAR model to handle spatial dependence in a Randomized Complete Block Design*

Description

Fit a randomized complete block design when the experimental units have some degree of spatial dependence using a Spatial Lag Model (SAR).

Usage

```
aovSar.rcbd(resp, treat, block, coord, seq.radius)
```

Arguments

resp	Numeric or complex vector containing the values of response variable.
treat	Numeric or complex vector containing the treatment applied to each experimental unit.
block	Numeric or complex vector specifying the blocks.
coord	Matrix of point coordinates or a SpatialPoints Object.
seq.radius	Complex vector containing a radii sequence used to set the neighborhood pattern. The default sequence has ten numbers from 0 to half of the maximum distance between the samples.

Details

Three assumptions are made about the error in the analysis of variance (ANOVA):

1. the errors are normally distributed and, on average, zero;

2. the errors all have the same variance (they are homoscedastic), and

3. the errors are unrelated to each other (they are independent across observations).

When these assumptions are not satisfied, data transformations in the response variable are often used to circumvent this problem. For example, in absence of normality, the Box-Cox transformation can be used.

However, in many experiments, especially field trials, there is a type of correlation generated by the sample locations known as spatial correlation, and this condition violates the independence assumption. In this setting, this function provides an alternative for using ANOVA when the errors are spatially correlated, by using a data transformation discussed in Long (1996)

$$Y_{adj} = Y - (\hat{\rho}WY - \hat{\rho}\beta_0),$$

where $\hat{\rho}$ denotes the autoregressive spatial parameter of the SAR model estimated by lagsarlm, β_0 is the overall mean and W is a spatial neighborhood matrix which neighbors are defined as the samples located within a radius, this radius is specified as a sequence in seq.radius. For each

radius in `seq.radius` the model is computed as well its AIC, then the radius chosen is the one that minimizes AIC.

The aim of this transformation is converting autocorrelated observations into non-correlated observations in order to apply the analysis of variance and obtain suitable inferences.

Value

`aovSar.rcbd` returns an object of [class](#) "SARanova". The functions summary and anova are used to obtain and print a summary and analysis of variance table of the results. An object of class "SARanova" is a list containing the following components:

DF	degrees of freedom of rho, treatments, residual and total.
SS	sum of squares of rho, treatments and residual.
Fc	F statistic calculated for treatment.
residuals	residuals of the adjusted model.
p.value	p-value associated to F statistic for treatment.
rho	the autoregressive parameter.
Par	data.frame with the radii tested and its AIC.
y_orig	vector of response.
y_ajus	vector of adjusted response.
treat	vector of treatment applied to each experimental unit.
modelAdj	model of class [aov](#) using the adjusted response.
modelstd	data frame containing the ANOVA table using non-adjusted response.
namey	response variable name.
namex	treatment variable name.

References

Long, D.S., 1996. Spatial statistics for analysis of variance of agronomic field trials. In: Arlinghaus, S.L. (Ed.), Practical Handbook of Spatial Statistics. CRC Press, Boca Raton, FL, pp. 251–278.

Rossoni, D. F.; Lima, R. R. . Autoregressive analysis of variance for experiments with spatial dependence between plots: a simulation study. Revista Brasileira de Biometria, 2019

Scolforo, Henrique Ferraço, et al. "Autoregressive spatial analysis and individual tree modeling as strategies for the management of Eremanthus erythropappus." Journal of forestry research 27.3 (2016): 595-603.

Examples

```
data("rcbd_simulated")

# Fitting the model
model <- aovSar.rcbd(rcbd_simulated$y, rcbd_simulated$trat, rcbd_simulated$block,
                     cbind(rcbd_simulated$coordX, rcbd_simulated$coordY))

# Summary for class SARanova
```

```
summary(model)

# Anova for class SARanova
anova(model)
```

---

contr.tuk   *Tukey's contrast matrix*

Description

Compute Tukey's contrast matrix

Usage

```
contr.tuk(x)
```

Arguments

x   a vector of means.

Details

Computes the matrix of contrasts for comparisons of mean levels.

Value

The matrix of contrasts with treatments in row names is returned

Examples

```
x <- c(10, 5, 8, 4, 12, 18)
contr.tuk(x)
```

---

crd_simulated   *Simulated data set for CRD*

Description

Simulated data set for CRD

Details

This dataset was simulated under a gaussian random field containing 15 treatments and 8 replication with mean 10.

Author(s)

Lucas Castro <lrcastro@estudante.ufla.br>

---

rcbd_simulated   *Simulated data set for RCBD*

Description

Simulated data set for RCBD

Details

This dataset was simulated under a gaussian random field containing 15 treatments and 3 blocks with 3 replication.

Author(s)

Lucas Castro <lrcastro@estudante.ufla.br>

---

spANOVAapp   *Shiny app for spANOVA*

Description

Shiny app for analysis of variance with spatially correlated errors

Usage

```
spANOVAapp(external = TRUE)
```

Arguments

external   logical. If true, the system's default web browser will be launched automatically
                 after the app is started.

Value

This function does not return any value directly. It launches a Shiny application for analyzing variance with spatially correlated errors.

Examples

```
spANOVAapp(external = TRUE)
```

Description

Compute cross-validation for an object of class spVariofit.

Usage

```
spCrossvalid(x, ...)
```

Arguments

x	an object of class spVariofit.
...	further arguments to be passed to xvalid function.

Details

This function is a wrapper to xvalid function of the package geoR. Please check its documentation for additional information.

Value

An object of the class "xvalid" which is a list with the following components:

data	the original data.
predicted	the values predicted by cross-validation.
krige.var	the cross-validation prediction variance.
error	the differences data - predicted value.
std.error	the errors divided by the square root of the prediction variances.
prob	the cumulative probability at original value under a normal distribution with parameters given by the cross-validation results.

Examples

```
data("crd_simulated")
dados <- crd_simulated

#Geodata object
geodados <- as.geodata(dados, coords.col = 1:2, data.col = 3,
                          covar.col = 4)
h_max <- summary(geodados)[[3]][[2]]
dist <- 0.6*h_max

# Computing the variogram
variograma <- spVariog(geodata = geodados,
                     trend = "cte", max.dist = dist, design = "crd",
```

```
                              scale = FALSE)

plot(variograma, ylab = "Semivariance", xlab = "Distance")

# Spherical Model
ols1 <- spVariofit(variograma, cov.model = "spherical", weights = "equal",
                   max.dist = dist)

#Using crossvalidation to assess the error
ols1.cv <- spCrossvalid(ols1)
```

---

spMVT   *Multiple comparison test based on multivariate t student distribution*

Description

Use a multivariate t student distribution to assess the equality of means.

Usage

```
spMVT(x, sig.level = 0.05, verbose = TRUE)

## S3 method for class 'SARanova'
spMVT(x, sig.level = 0.05, verbose = TRUE)

## S3 method for class 'GEOanova'
spMVT(x, sig.level = 0.05, verbose = TRUE)
```

Arguments

x	a fitted model object of class SARcrd, SARrcbd or GEOanova.
sig.level	a numeric value between zero and one giving the significance level to use.
verbose	should messages be printed during loading?

Details

For objects of class SARcrd or SARrcbd this function performs the general linear hypothesis method provided by the function glht on the adjusted response.

For objects of class GEOanova, the test is modified to accommodate the spatial dependence among the observations as pointed out by Nogueira (2017)

Value

a data frame containing the original mean, the spatially filtered mean and its group. For the class GEOanova, the spatial dependence is filtered out using geostatistics, while for the class SARanova the adjusted response based on SAR model is employed.

References

Nogueira, C. H. Testes para comparações múltiplas de médias em experimentos com tendência e dependência espacial. 142 f. Tese (Doutorado em Estatística e Experimentação Agropecuária) | Universidade Federal de Lavras, Lavras, 2017

Examples

```
data("crd_simulated")

#Geodata object
geodados <- as.geodata(crd_simulated, coords.col = 1:2, data.col = 3,
                       covar.col = 4)
h_max <- summary(geodados)[[3]][[2]]
dist <- 0.6*h_max

# Computing the variogram
variograma <- spVariog(geodata = geodados,
                       trend = "cte", max.dist = dist, design = "crd",
                       scale = FALSE)

plot(variograma, ylab = "Semivariance", xlab = "Distance")

# Gaussian Model
ols <- spVariofit(variograma, cov.model = "gaussian", weights = "equal",
                  max.dist = dist)

lines(ols, col = 1)

# Compute the model and get the analysis of variance table
mod <- aovGeo(ols, cutoff = 0.6)

# Multivariate T test
spMVT(mod)
```

---

spScottKnott	*The Scott-Knott Clustering Algorithm*

Description

This function implements the Scott-Knott Clustering Algorithm for objects of class SARcrd, SARrcbd, and GEOanova.

Usage

```
spScottKnott(x, sig.level = 0.05, verbose = TRUE)
```

```
## S3 method for class 'SARanova'
spScottKnott(x, sig.level = 0.05, verbose = TRUE)

## S3 method for class 'GEOanova'
spScottKnott(x, sig.level = 0.05, verbose = TRUE)
```

Arguments

x	a fitted model object of class SARcrd, SARrcbd or GEOanova.
sig.level	a numeric value between zero and one giving the significance level to use.
verbose	should messages be printed during loading?

Details

For objects of class SARcrd or SARrcbd this function performs the standard Scott-Knott Clustering Algorithm provided by the function SK on the adjusted response.

For objects of class GEOanova, the method is modified to take into account the spatial dependence among the observations. The method is described in Nogueira (2017).

Value

a data frame containing the means and its group

References

Nogueira, C. H. Testes para comparações múltiplas de médias em experimentos com tendência e dependência espacial. 142 f. Tese (Doutorado em Estatística e Experimentação Agropecuária) | Universidade Federal de Lavras, Lavras, 2017

Examples

```
data("crd_simulated")

#Geodata object
geodados <- as.geodata(crd_simulated, coords.col = 1:2, data.col = 3,
                       covar.col = 4)
h_max <- summary(geodados)[[3]][[2]]
dist <- 0.6*h_max

# Computing the variogram
variograma <- spVariog(geodata = geodados,
                       trend = "cte", max.dist = dist, design = "crd",
                       scale = FALSE)

plot(variograma, ylab = "Semivariance", xlab = "Distance")

# Gaussian Model
ols <- spVariofit(variograma, cov.model = "gaussian", weights = "equal",
                  max.dist = dist)
```

```
# Compute the model and get the analysis of variance table
mod <- aovGeo(ols, cutoff = 0.6)

# Scott-Knott clustering algorithm
spScottKnott(mod)
```

---

spTukey	*Compute Tukey Honest Significant Differences for a Spatially Corre-lated Model*

Description

Perform multiple comparisons of means treatments based on the Studentized range statistic when the errors are spatially correlated.

Usage

```
spTukey(x, sig.level = 0.05, verbose = TRUE)

## S3 method for class 'SARanova'
spTukey(x, sig.level = 0.05, verbose = TRUE)

## S3 method for class 'GEOanova'
spTukey(x, sig.level = 0.05, verbose = TRUE)
```

Arguments

x	A fitted model object of class SARcrd, SARrcbd or GEOanova.
sig.level	A numeric value between zero and one giving the significance level to use.
verbose	should messages be printed during loading?

Details

For objects of class SARcrd or SARrcbd this function performs the standard Tukey's 'Honest Significant Difference' method provided by the function [TukeyHSD] on the adjusted response.

For objects of class GEOanova, the method is modified to take into account the spatial dependence among the observations. First, we estimate a contrast matrix (C) using cont.tuk function and then after estimate the spatial mean of each treatment (μ_i) we can assess the significance of the contrast by

$$|c_i\mu_i| > HSD_i$$

where $HSD_i = q(\alpha, k, \nu) * sqrt(0.5 * w_i i)$ and k is the number of treatments, α is the level of significance, ν is the degree of freedom of the model, $w_i i$ is the variance of the i-th contrast.

Value

a data frame containing the original mean, the spatially filtered mean and its group. For the class GEOanova, the spatial dependence is filtered out using geostatistics, while for the class SARanova the adjusted response based on SAR model is employed.

References

Nogueira, C. H. Testes para comparações múltiplas de médias em experimentos com tendência e dependência espacial. 142 f. Tese (Doutorado em Estatística e Experimentação Agropecuária) | Universidade Federal de Lavras, Lavras, 2017

Examples

```
data("crd_simulated")

#Geodata object
geodados <- as.geodata(crd_simulated, coords.col = 1:2, data.col = 3,
                       covar.col = 4)
h_max <- summary(geodados)[[3]][[2]]
dist <- 0.6*h_max

# Computing the variogram
variograma <- spVariog(geodata = geodados,
                       trend = "cte", max.dist = dist, design = "crd",
                       scale = FALSE)

plot(variograma, ylab = "Semivariance", xlab = "Distance")

# Gaussian Model
ols <- spVariofit(variograma, cov.model = "gaussian", weights = "equal",
                  max.dist = dist)

lines(ols, col = 1)

# Compute the model and get the analysis of variance table
mod <- aovGeo(ols, cutoff = 0.6)

# Tukey's HSD
spTukey(mod)
```

---

spVariofit   *Fit a variogram model*

Description

Fit a parametric model to a variogram created by the function spVariog.

Usage

```
spVariofit(x, ...)
```

Arguments

x	an object of class spVariog.
...	further arguments to be passed to variofit function.

Details

This function is a wrapper to variofit and can be used to fit a parametric model to a variogram using either ordinary least squares or weighted least squares. It takes as the main argument a spVariog object and others arguments should be passed to . . . such as "cov.model" and so on.

Value

an object of class SpVariofit which is a list containing the following components:

mod	an object of class variofit
data.geo	an object of class geodata
des.mat	the design matrix
trend	a character specifying the type of spatial trend

See Also

variofit

Examples

```
data("crd_simulated")
dados <- crd_simulated

#Geodata object
geodados <- as.geodata(dados, coords.col = 1:2, data.col = 3,
                       covar.col = 4)
h_max <- summary(geodados)[[3]][[2]]
dist <- 0.6*h_max

# Computing the variogram
variograma <- spVariog(geodata = geodados,
                       trend = "cte", max.dist = dist, design = "crd",
                       scale = FALSE)

plot(variograma, ylab = "Semivariance", xlab = "Distance")

# Spherical Model
ols1 <- spVariofit(variograma, cov.model = "spherical", weights = "equal",
                   max.dist = dist)
lines(ols1)
```

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spVariog   *Compute empirical residual variogram for CRD or RCBD.*

Description

Compute empirical residual variogram for a Completely Randomized Design (CRD) or a Randomized Complete Block Design (RCBD) by a call to variog function of the package geoR.

Usage

```
spVariog(geodata, resp = NULL, treat = NULL, block = NULL, coords = NULL,
data = NULL, trend = c("cte", "1st"), scale = FALSE, max.dist,
design = c("crd", "rcbd"), ...)
```

Arguments

geodata	an object of class geodata in which the response variable should be given in 'data.col', the coordinates in 'coords.col', the treatment vector should be given as the first column of 'covar.col' and block as the second one.
resp	either a vector of response variables or a character giving the column name where it can be found in 'data'. Optional argument, just required if geodata is not provided.
treat	either a vector of treatment factors or a character giving the column name where it can be found in 'data'. Optional argument, just required if geodata is not provided.
block	either a vector of block factors or a character giving the column name where it can be found in 'data'. Optional argument, just required if geodata is not provided.
coords	either a 2-column matrix containing the spatial coordinates or a character vector giving the columns name where the coordinates can be found in 'data'. Optional argument, just required if geodata is not provided.
data	a data frame in which the variables specified as characters will be found. Optional argument, just required if geodata is not provided.
trend	type of spatial trend considered.
scale	logical argument. Should the coordinates be scaled? We recommend this argument to be set as TRUE if your spatial coordinates have high values as in UTM coordinate system otherwise, you could get errors in the calculations. See 'Details'.
max.dist	numerical value defining the maximum distance for the variogram. See [variog](#) documentation for additional information.
design	type of experimental design. "crd" corresponds to Completely Randomized Design and "rcbd" corresponds to Randomized Complete Block Design.
...	further arguments to be passed to [variog](#) function.

Details

This function provides a wrapper to variog to compute residual variogram for experimental designs. The residuals are obtained by

$$\varepsilon = Y - X\beta,$$

where Y is the vector of response, X is the design matrix built according to the experimental design chosen, and β is the vector of coefficients estimated by the linear model.

If scale = TRUE the spatial coordinates will be scaled for numerical reasons. The scale is made by subtracting the minimum spatial coordinate value from all others.

Value

An object of class spVariog which is a list with the following components:

vario.res	an object of class variogram
data.geo	an object of class geodata
des.mat	the design matrix
trend	a character specifying the type of spatial trend

See Also

variog

Examples

```
data("crd_simulated")
dados <- crd_simulated

#Geodata object
geodados <- as.geodata(dados, coords.col = 1:2, data.col = 3,
                            covar.col = 4)
h_max <- summary(geodados)[[3]][[2]]
dist <- 0.6*h_max

# Computing the variogram
variograma <- spVariog(geodata = geodados,
                    trend = "cte", max.dist = dist, design = "crd",
                    scale = FALSE)

plot(variograma, ylab = "Semivariance", xlab = "Distance")
```

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