Package ‘gstat’

March 14, 2022

Version  2.0-9
Title    Spatial and Spatio-Temporal Geostatistical Modelling, Prediction
         and Simulation
Description Variogram modelling; simple, ordinary and universal point or block (co)kriging; spatio-
         temporal kriging; sequential Gaussian or indicator (co)simulation; variogram and vari-
         ogram map plotting utility functions; supports sf and stars.
Depends  R (>= 2.10)
Imports  utils, stats, graphics, methods, lattice, sp (>= 0.9-72), zoo,
         spacetime (>= 1.0-0), FNN
Suggests fields, maps, mapdata, maptools, rgdal (>= 0.5.2), rgeos, sf
         (>= 0.7-2), stars (>= 0.3-0), xts, raster, future, future.apply
License  GPL (>= 2.0)
URL      https://github.com/r-spatial/gstat/
Encoding UTF-8
BugReports https://github.com/r-spatial/gstat/issues/
NeedsCompilation yes
RoxygenNote 6.1.1
Author    Edzer Pebesma [aut, cre] (https://orcid.org/0000-0001-8049-7069),
          Benedikt Graepler [aut]
Maintainer Edzer Pebesma <edzer.pebesma@uni-muenster.de>
Repository CRAN
Date/Publication 2022-03-14 15:20:05 UTC

R topics documented:

coalash ........................................... 3
DE_RB_2005 ........................................ 4
estiStAni .......................................... 5
extractPar ........................................ 6
fit.lmc ............................................ 7
R topics documented:

fit.StVariogram ............................................................. 8
fit.variogram ............................................................... 11
fit.variogram.gls ......................................................... 13
fit.variogram.reml ....................................................... 14
fulmar ................................................................. 15
get.contr ............................................................. 16
gstat .............................................................. 17
hscat .......................................................... 21
image ........................................................... 22
jura ............................................................ 24
krige .......................................................... 26
krige.cv ......................................................... 30
krigeSimCE ........................................................ 33
krigeST .......................................................... 34
krigeSTSimTB ..................................................... 36
krigeTg ........................................................ 38
map.to.lev .......................................................... 40
meuse.all ......................................................... 40
meuse.alt ......................................................... 42
ncp.grid .......................................................... 43
ossfim ........................................................ 44
oxford ........................................................ 45
pcb .......................................................... 47
plot.gstatVariogram ............................................... 48
plot.pointPairs ..................................................... 50
plot.variogramCloud ............................................... 52
predict .......................................................... 53
progress ........................................................ 57
show.vgms .......................................................... 58
sic2004 .......................................................... 59
sic97 .......................................................... 61
spplot.vcov .......................................................... 62
tull .......................................................... 63
variogram .......................................................... 65
variogramLine .......................................................... 69
variogramST .......................................................... 70
variogramSurface ..................................................... 72
vgm .......................................................... 73
vgm.panel.xyplot ................................................... 76
vgmArea .......................................................... 78
vgmAreaST .......................................................... 79
vgmST .......................................................... 80
vv .......................................................... 82
walker ......................................................... 83
wind .......................................................... 84

Index .......................................................... 87
coalash

---

**coalash**

*Coal ash samples from a mine in Pennsylvania*

**Description**

Data obtained from Gomez and Hazen (1970, Tables 19 and 20) on coal ash for the Robena Mine Property in Greene County Pennsylvania.

**Usage**

`data(coalash)`

**Format**

This data frame contains the following columns:

- `x` a numeric vector; x-coordinate; reference unknown
- `y` a numeric vector; x-coordinate; reference unknown
- `coalash` the target variable

**Note**

data are also present in package fields, as coalash.

**Author(s)**

unknown; R version prepared by Edzer Pebesma; data obtained from [http://homepage.divms.uiowa.edu/~dzimmer/spatialstats/](http://homepage.divms.uiowa.edu/~dzimmer/spatialstats/), Dale Zimmerman’s course page

**References**


**Examples**

```r
data(coalash)
summary(coalash)
```
## Description

Spatio-temporal data set with rural background PM10 concentrations in Germany 2005 (airbase v6).

## Usage

```r
data("DE_RB_2005")
```

## Format

The format is: Formal class 'STSDF' [package "spacetime"] with 5 slots.

```r
@ data : 'data.frame': 23230 obs. of 2 variables:
  ..$ PM10 : num [1:23230] 16.7 31.7 5 22.4 26.8 ...  
  ..$ logPM10: num [1:23230] 2.82 3.46 1.61 3.11 3.29 ...  

@ index : int [1:23230, 1:2] 1 2 3 4 5 6 7 8 9 10 ...  

@ sp : Formal class 'SpatialPointsDataFrame' [package "sp"] with 5 slots.
```n

## Source

EEA, airbase v6
Examples

```r
data(DE_RB_2005)
str(DE_RB_2005)
```

---

**estiStAni**

*Estimation of the spatio-temporal anisotropy*

---

**Description**

Estimation of the spatio-temporal anisotropy without an underlying spatio-temporal model. Different methods are implemented using a linear model to predict the temporal gamma values or the ratio of the ranges of a spatial and temporal variogram model or a spatial variogram model to predict the temporal gamma values or the spatio-temporal anisotropy value as used in a metric spatio-temporal variogram.

**Usage**

```r
estiStAni(empVgm, interval, method = "linear", spatialVgm, temporalVgm, s.range=NA, t.range=NA)
```

**Arguments**

- `interval`: A search interval for the optimisation of the spatio-temporal anisotropy parameter.
- `method`: A character string determining the method to be used (one of `linear`, `range`, `vgm` or `metric`, see below for details).
- `spatialVgm`: A spatial variogram definition from the call to `vgm`. The model is optimised based on the pure spatial values in `empVgm`.
- `temporalVgm`: A temporal variogram definition from the call to `vgm`. The model is optimised based on the pure temporal values in `empVgm`.
- `s.range`: A spatial cutoff value applied to the empirical variogram `empVgm`.
- `t.range`: A temporal cutoff value applied to the empirical variogram `empVgm`.

**Details**

- **linear** A linear model is fitted to the pure spatial gamma values based on the spatial distances. An optimal scaling is searched to stretch the temporal distances such that the linear model explains best the pure temporal gamma values. This assumes (on average) a linear relationship between distance and gamma, hence it is advisable to use only those pairs of pure spatial (pure temporal) distance and gamma value that show a considerable increase (i.e. drop all values beyond the range by setting values for `s.range` and `t.range`).

- **range** A spatial and temporal variogram model is fitted to the pure spatial and temporal gamma values respectively. The spatio-temporal anisotropy estimate is the ratio of the spatial range over the temporal range.
vgm  A spatial variogram model is fitted to the pure spatial gamma values. An optimal scaling is used to stretch the temporal distances such that the spatial variogram model explains best the pure temporal gamma values.

metric  A metric spatio-temporal variogram model is fitted with joint component according to the defined spatial variogram spatialVgm. The starting value of stAni is the mean of the interval parameter (see vgmST for the metric variogram definition). The spatio-temporal anisotropy as estimated in the spatio-temporal variogram is returned. Note that the parameter interval is only used to set the starting value. Hence, the estimate might exceed the given interval.

Value

A scalar representing the spatio-temporal anisotropy estimate.

Note

Different methods might lead to very different estimates. All but the linear approach are sensitive to the variogram model selection.

Author(s)

Benedikt Graeler

Examples

data(vv)

estiStAni(vv, c(10, 150))
estiStAni(vv, c(10, 150), "vgm", vgm(80, "Sph", 120, 20))

extractPar

Extracting parameters and their names from a spatio-temporal variogram model

Description

All spatio-temporal variogram models have a different set of parameters. These functions extract the parameters and their names from the spatio-temporal variogram model. Note, this function is as well used to pass the parameters to the optim function. The arguments lower and upper passed to optim should follow the same structure.

Usage

extractPar(model)
extractParNames(model)

Arguments

model  a spatio-temporal variogram model from vgmST
Value

A named numeric vector of parameters or a vector of characters holding the parameters’ names.

Author(s)

Benedikt Graeler

See Also

fit.StVariogram and vgmST

Examples

```r
sumMetricModel <- vgmST("sumMetric",
  space=vgm(30, "Sph", 200, 6),
  time =vgm(30, "Sph", 15, 7),
  joint=vgm(60, "Exp", 84, 22),
  stAni=100)

extractPar(sumMetricModel)
extractParNames(sumMetricModel)
```

fit.lmc

Fit a Linear Model of Coregionalization to a Multivariable Sample Variogram

Description

Fit a Linear Model of Coregionalization to a Multivariable Sample Variogram; in case of a single variogram model (i.e., no nugget) this is equivalent to Intrinsic Correlation

Usage

```r
fit.lmc(v, g, model, fit.ranges = FALSE, fit.lmc = !fit.ranges,
 correct.diagonal = 1.0, ...)
```

Arguments

- `v`: multivariable sample variogram, output of `variogram`
- `g`: gstat object, output of `gstat`
- `model`: variogram model, output of `vgm`; if supplied this value is used as initial value for each fit
- `fit.ranges`: logical; determines whether the range coefficients (excluding that of the nugget component) should be fitted; or logical vector: determines for each range parameter of the variogram model whether it should be fitted or fixed.
- `fit.lmc`: logical; if TRUE, each coefficient matrices of partial sills is guaranteed to be positive definite
correct.diagonal

multiplicative correction factor to be applied to partial sills of direct variograms only; the default value, 1.0, does not correct. If you encounter problems with singular covariance matrices during cokriging or cosimulation, you may want to try to increase this to e.g. 1.01

... parameters that get passed to fit.variogram

Value

returns an object of class gstat, with fitted variograms;

Note

This function does not use the iterative procedure proposed by M. Goulard and M. Voltz (Math. Geol., 24(3): 269-286; reproduced in Goovaerts’ 1997 book) but uses simply two steps: first, each variogram model is fitted to a direct or cross variogram; next each of the partial sill coefficient matrices is approached by its in least squares sense closest positive definite matrices (by setting any negative eigenvalues to zero).

The argument correct.diagonal was introduced by experience: by zeroing the negative eigenvalues for fitting positive definite partial sill matrices, apparently still perfect correlation may result, leading to singular cokriging/cosimulation matrices. If someone knows of a more elegant way to get around this, please let me know.

Author(s)

Edzer Pebesma

References

http://www.gstat.org/

See Also

variogram, vgm, fit.variogram, demo(cokriging)
Arguments

object The spatio-temporal sample variogram. Typically output from \texttt{variogramST}.
model The desired spatio-temporal model defined through \texttt{vgmST}.

... further arguments passed to \texttt{optim}. \texttt{extractParNames} provides the parameter structure of spatio-temporal variogram models that help to provide sensible upper and lower limits.

lower Lower limits used by optim. If missing, the smallest well defined values are used (mostly near 0).
upper Upper limits used by optim. If missing, the largest well defined values are used (mostly \texttt{Inf}).

method fit method, pass to \texttt{optim}.
fit.method an integer between 0 and 13 determine the fitting routine (i.e. weighting of the squared residuals in the LSE). Values 0 to 6 correspond with the pure spatial version (see \texttt{fit.variogram}). See the details section for the meaning of the other values (partly experimental).

stAni The spatio-temporal anisotropy that is used in the weighting. Might be missing if the desired spatio-temporal variogram model does contain a spatio-temporal anisotropy parameter (this might cause bad convergence behaviour). The default is \texttt{NA} and will be understood as identity (1 temporal unit = 1 spatial unit). As this only in very few cases a valid assumption, a warning is issued.
wles Should be missing; only for backwards compatibility, \texttt{wles = TRUE} corresponds to \texttt{fit.method = 1} and \texttt{wles = FALSE} corresponds to \texttt{fit.method = 6}.

Details

The following list summarizes the meaning of the \texttt{fit.method} argument which is essential a weighting of the squared residuals in the least-squares estimation. Please note, that weights based on the models gamma value might fail to converge properly due to the dependence of weights on the variogram estimate:

\begin{itemize}
  \item \texttt{fit.method = 0} no fitting, however the MSE between the provided variogram model and sample variogram surface is calculated.
  \item \texttt{fit.method = 1} Number of pairs in the spatio-temporal bin: \(N_j\)
  \item \texttt{fit.method = 2} Number of pairs in the spatio-temporal bin divided by the square of the current variogram model’s value: \(N_j/\gamma(h_j, u_j)^2\)
  \item \texttt{fit.method = 3} Same as \texttt{fit.method = 1} for compatibility with \texttt{fit.variogram} but as well evaluated in R.
  \item \texttt{fit.method = 4} Same as \texttt{fit.method = 2} for compatibility with \texttt{fit.variogram} but as well evaluated in R.
  \item \texttt{fit.method = 5} Reserved for REML for compatibility with \texttt{fit.variogram}, not yet implemented.
  \item \texttt{fit.method = 6} No weights.
  \item \texttt{fit.method = 7} Number of pairs in the spatio-temporal bin divided by the square of the bin’s metric distance. If \texttt{stAni} is not specified, the model’s parameter is used to calculate the metric distance across space and time: \(N_j/(h_j^2 + \text{stAni}^2 \cdot u_j^2)\)
\end{itemize}
fit.method = 8 Number of pairs in the spatio-temporal bin divided by the square of the bin's spatial distance. \( N_j / h_j^2 \). Note that the 0 distances are replaced by the smallest non-zero distances to avoid division by zero.

fit.method = 9 Number of pairs in the spatio-temporal bin divided by the square of the bin's temporal distance. \( N_j / u_j^2 \). Note that the 0 distances are replaced by the smallest non-zero distances to avoid division by zero.

fit.method = 10 Reciprocal of the square of the current variogram model’s value: \( 1 / \gamma(h_j, u_j)^2 \)

fit.method = 11 Reciprocal of the square of the bin’s metric distance. If stAni is not specified, the model’s parameter is used to calculate the metric distance across space and time: \( 1 / (h_j^2 + stAni^2 \cdot u_j^2) \)

fit.method = 12 Reciprocal of the square of the bin’s spatial distance. \( 1 / h_j^2 \). Note that the 0 distances are replaced by the smallest non-zero distances to avoid division by zero.

fit.method = 13 Reciprocal of the square of the bin’s temporal distance. \( 1 / u_j^2 \). Note that the 0 distances are replaced by the smallest non-zero distances to avoid division by zero.

See also Table 4.2 in the gstat manual for the original spatial version.

Value

Returns a spatio-temporal variogram model, as S3 class StVariogramModel. It carries the temporal and spatial unit as attributes "temporal unit" and "spatial unit" in order to allow krigiST to adjust for different units. The units are obtained from the provided empirical variogram. Further attributes are the optim output "optim.output" and the always not weighted mean squared error "MSE".

Author(s)

Benedikt Graeler

See Also

fit.variogram for the pure spatial case. extractParNames helps to understand the parameter structure of spatio-temporal variogram models.

Examples

# separable model: spatial and temporal sill will be ignored
# and kept constant at 1-nugget respectively. A joint sill is used.
## Not run:
separableModel <- vgmST("separable",
    method = "Nelder-Mead", # no lower & upper needed
    space=vgm(0.9,"Exp", 123, 0.1),
    time =vgm(0.9,"Exp", 2.9, 0.1),
    sill=100)

data(vv)
separableModel <- fit.StVariogram(vv, separableModel,
    method="L-BFGS-B",
    lower=c(10,0,0.01,0,1),
    ...
plot(vv, separableModel)
## End(Not run) # dontrun

### Description

Fit ranges and/or sills from a simple or nested variogram model to a sample variogram

### Usage

```r
fit.variogram(object, model, fit.sills = TRUE, fit.ranges = TRUE,
               fit.method = 7, debug.level = 1, warn.if.neg = FALSE, fit.kappa = FALSE)
```

### Arguments

- **object**: sample variogram, output of `variogram`
- **model**: variogram model, output of `vgm`; see Details below for details on how NA values in `model` are initialised.
- **fit.sills**: logical; determines whether the partial sill coefficients (including nugget variance) should be fitted; or logical vector: determines for each partial sill parameter whether it should be fitted or fixed.
- **fit.ranges**: logical; determines whether the range coefficients (excluding that of the nugget component) should be fitted; or logical vector: determines for each range parameter whether it should be fitted or fixed.
- **fit.method**: fitting method, used by gstat. The default method uses weights $N_h/h^2$ with $N_h$ the number of point pairs and $h$ the distance. This criterion is not supported by theory, but by practice. For other values of `fit.method`, see details.
- **debug.level**: integer; set gstat internal debug level
- **warn.if.neg**: logical; if TRUE a warning is issued whenever a sill value of a direct variogram becomes negative
- **fit.kappa**: logical; if TRUE, a sequence of 0.3, 0.4,...,5 will be searched for optimal fit; alternatively another sequence can be given to this argument

### Details

If any of the initial parameters of `model` are NA, they are given default values as follows. The range parameter is given one third of the maximum value of `object$dist`. The nugget value is given the mean value of the first three values of `object$gamma`. The partial sill is given the mean of the last five values of `object$gamma`. The partial sill is given the mean of the last five values of `object$gamma`.

Values for `fit.method` are 1: weights equal to $N_j$; 2: weights equal to $N_j/(\gamma(h_j)^2)$; 5 (ignore, use `fit.variogram.reml`); 6: unweighted (OLS); 7: $N_j/(h_j^2)$. (from: [http://www.gstat.org/gstat.pdf](http://www.gstat.org/gstat.pdf), table 4.2).
Value

returns a fitted variogram model (of class variogramModel).
This is a data.frame with two attributes: (i) singular a logical attribute that indicates whether
the non-linear fit converged (FALSE), or ended in a singularity (TRUE), and (ii) SSErr a numerical
attribute with the (weighted) sum of squared errors of the fitted model. See Notes below.

Note

If fitting the range(s) is part of the job of this function, the results may well depend on the starting
values, given in argument model, which is generally the case for non-linear regression problems.
This function uses internal C code, which uses Levenberg-Marquardt.
If for a direct (i.e. not a cross) variogram a sill parameter (partial sill or nugget) becomes negative,
fit.variogram is called again with this parameter set to zero, and with a FALSE flag to further fit this
sill. This implies that the search does not move away from search space boundaries.
On singular model fits: If your variogram turns out to be a flat, horizontal or sloping line, then fitting
a three parameter model such as the exponential or spherical with nugget is a bit heavy: there’s an
infinite number of possible combinations of sill and range (both very large) to fit to a sloping line. In
this case, the returned, singular model may still be useful: just try and plot it. Gstat converges when
the parameter values stabilize, and this may not be the case. Another case of singular model fits
happens when a model that reaches the sill (such as the spherical) is fit with a nugget, and the range
parameter starts, or converges to a value smaller than the distance of the second sample variogram
estimate. In this case, again, an infinite number of possibilities occur essentially for fitting a line
through a single (first sample variogram) point. In both cases, fixing one or more of the variogram
model parameters may help you out.

Author(s)

Edzer Pebesma

References

http://www.gstat.org/


See Also

variogram, vgm

Examples

library(sp)
data(meuse)
coordinates(meuse) = ~x+y
vgm1 <- variogram(log(zinc)~1, meuse)
fit.variogram(vgm1, vgm(1, "Sph", 300, 1))
fit.variogram(vgm1, vgm("Sph"))
# optimize the value of kappa in a Matern model, using ugly <<- side effect:
f = function(x) attr(m.fit <<- fit.variogram(vgm1, vgm("Mat", nugget=NA, kappa=x)),"SSErr")
optimize(f, c(0.1, 5))
plot(vgm1, m.fit)
# best fit from the (0.3, 0.4, 0.5, ..., 5) sequence:
(m <- fit.variogram(vgm1, vgm("Mat"), fit.kappa = TRUE))
attr(m, "SSErr")

fit.variogram.gls

GLS fitting of variogram parameters

Description

Fits variogram parameters (nugget, sill, range) to variogram cloud, using GLS (generalized least squares) fitting. Only for direct variograms.

Usage

fit.variogram.gls(formula, data, model, maxiter = 30,
eps = .01, trace = TRUE, ignoreInitial = TRUE, cutoff = Inf,
plot = FALSE)

Arguments

  formula     formula defining the response vector and (possible) regressors; in case of absence of regressors, use e.g. z~1
  data        object of class Spatial
  model       variogram model to be fitted, output of vgm
  maxiter     maximum number of iterations
  eps         convergence criterium
  trace       logical; if TRUE, prints parameter trace
  ignoreInitial   logical; if FALSE, initial parameter are taken from model; if TRUE, initial values of model are ignored and taken from variogram cloud: nugget: mean(y)/2, sill: mean(y)/2, range median(h0)/4 with y the semivariance cloud value and h0 the distances
  cutoff      maximum distance up to which point pairs are taken into consideration
  plot        logical; if TRUE, a plot is returned with variogram cloud and fitted model; else, the fitted model is returned.

Value

an object of class "variogramModel"; see fit.variogram; if plot is TRUE, a plot is returned instead.

Note

Inspired by the code of Mihael Drinovac, which was again inspired by code from Ernst Glatzer, author of package vardiag.
fit.variogram.reml

REML Fit Direct Variogram Partial Sills to Data

Description

Fit Variogram Sills to Data, using REML (only for direct variograms; not for cross variograms)

Usage

fit.variogram.reml(formula, locations, data, model, debug.level = 1, set, degree = 0)

Arguments

formula formula defining the response vector and (possible) regressors; in case of absence of regressors, use e.g. z~1
locations spatial data locations; a formula with the coordinate variables in the right hand (dependent variable) side.
data data frame where the names in formula and locations are to be found
model variogram model to be fitted, output of vgm
debug.level debug level; set to 65 to see the iteration trace and log likelihood
set additional options that can be set; use set=list(iter=100) to set the max. number of iterations to 100.
degree order of trend surface in the location, between 0 and 3
fulmar

Value

an object of class "variogramModel"; see fit.variogram

Note

This implementation only uses REML fitting of sill parameters. For each iteration, an $n \times n$ matrix is inverted, with $n$ the number of observations, so for large data sets this method becomes demanding. I guess there is much more to likelihood variogram fitting in package geoR, and probably also in nlme.

Author(s)

Edzer Pebesma

References


See Also

fit.variogram,

Examples

library(sp)
data(meuse)
fit.variogram.reml(log(zinc)~1, ~x+y, meuse, model = vgm(1, "Sph", 900,1))

fulmar Fulmaris glacialis data

Description

Airborne counts of Fulmaris glacialis during the Aug/Sept 1998 and 1999 flights on the Dutch (Netherlands) part of the North Sea (NCP, Nederlands Continentaal Plat).

Usage

data(fulmar)
Format

This data frame contains the following columns:

- **year**: year of measurement: 1998 or 1999
- **x**: x-coordinate in UTM zone 31
- **y**: y-coordinate in UTM zone 31
- **depth**: sea water depth, in m
- **coast**: distance to coast of the Netherlands, in km.
- **fulmar**: observed density (number of birds per square km)

Author(s)

Dutch National Institute for Coastal and Marine Management (RIKZ)

See Also

- ncp.grid


Examples

```r
data(fulmar)
summary(fulmar)
## Not run:
demo(fulmar)
## End(Not run)
```

---

### get.contr

*Calculate contrasts from multivariable predictions*

**Description**

Given multivariable predictions and prediction (co)variances, calculate contrasts and their (co)variance

**Usage**

```r
get.contr(data, gstat.object, X, ids = names(gstat.object$data))
```

**Arguments**

- **data**: data frame, output of `predict`
- **gstat.object**: object of class `gstat`, used to extract ids; may be missing if `ids` is used
- **X**: contrast vector or matrix; the number of variables in `gstat.object` should equal the number of elements in `X` if `X` is a vector, or the number of rows in `X` if `X` is a matrix.
- **ids**: character vector with (selection of) id names, present in data
Details

From data, we can extract the $n \times 1$ vector with multivariable predictions, say $y$, and its $n \times n$ covariance matrix $V$. Given a contrast matrix in $X$, this function computes the contrast vector $C=X'y$ and its variance $\text{Var}(C)=X'VX$.

Value

A data frame containing for each row in data the generalized least squares estimates (named beta.1, beta.2, ...), their variances (named var.beta.1, var.beta.2, ...) and covariances (named cov.beta.1.2, cov.beta.1.3, ...)

Author(s)

Edzer Pebesma

References

http://www.gstat.org/

See Also

predict

Usage

gstat(g, id, formula, locations, data, model = NULL, beta, nmax = Inf, nmin = 0, omax = 0, maxdist = Inf, force = FALSE, dummy = FALSE, set, fill.all = FALSE, fill.cross = TRUE, variance = "identity", weights = NULL, merge, degree = 0, vdist = FALSE, lambda = 1.0)

# S3 method for class 'gstat'
print(x, ...)

gstat Create gstat objects, or subset it

Description

Function that creates gstat objects; objects that hold all the information necessary for univariate or multivariate geostatistical prediction (simple, ordinary or universal (co)kriging), or its conditional or unconditional Gaussian or indicator simulation equivalents. Multivariate gstat object can be subsetted.

Usage

gstat(g, id, formula, locations, data, model = NULL, beta, nmax = Inf, nmin = 0, omax = 0, maxdist = Inf, force = FALSE, dummy = FALSE, set, fill.all = FALSE, fill.cross = TRUE, variance = "identity", weights = NULL, merge, degree = 0, vdist = FALSE, lambda = 1.0)

# S3 method for class 'gstat'
print(x, ...)
Arguments

- **g**: gstat object to append to; if missing, a new gstat object is created.
- **id**: identifier of new variable; if missing, `varn` is used with `n` the number for this variable. If a cross variogram is entered, `id` should be a vector with the two `id` values, e.g., `c("zn", "cd")`, further only supplying arguments `g` and `model`. It is advisable not to use expressions, such as `log(zinc)`, as identifiers, as this may lead to complications later on.
- **formula**: formula that defines the dependent variable as a linear model of independent variables; suppose the dependent variable has name `z`, for ordinary and simple kriging use the formula `z~1`; for simple kriging also define `beta` (see below); for universal kriging, suppose `z` is linearly dependent on `x` and `y`, use the formula `z~x+y`.
- **locations**: formula with only independent variables that define the spatial data locations (coordinates), e.g., `~x+y`; if data has a `coordinates` method to extract its coordinates this argument can be ignored (see package sp for classes for point or grid data).
- **data**: data frame; contains the dependent variable, independent variables, and locations.
- **model**: variogram model for this `id`; defined by a call to `vgm`; see argument `id` to see how cross variograms are entered.
- **beta**: for simple kriging (and simulation based on simple kriging): vector with the trend coefficients (including intercept); if no independent variables are defined the model only contains an intercept and this should be the expected value; for cross variogram computations: mean parameters to be used instead of the OLS estimates.
- **nmax**: for local kriging: the number of nearest observations that should be used for a kriging prediction or simulation, where nearest is defined in terms of the space of the spatial locations.
- **nmin**: for local kriging: if the number of nearest observations within distance `maxdist` is less than `nmin`, a missing value will be generated, unless `force==TRUE`; see `maxdist`.
- **omax**: maximum number of observations to select per octant (3D) or quadrant (2D); only relevant if `maxdist` has been defined as well.
- **maxdist**: for local kriging: only observations within a distance of `maxdist` from the prediction location are used for prediction or simulation; if combined with `nmax`, both criteria apply.
- **force**: for local kriging, force neighbourhood selection: in case `nmin` is given, search beyond `maxdist` until `nmin` neighbours are found. A missing value is returned if this is not possible.
- **dummy**: logical; if `TRUE`, consider this data as a dummy variable (only necessary for unconditional simulation).
- **set**: named list with optional parameters to be passed to gstat (only `set` commands of gstat are allowed, and not all of them may be relevant; see the manual for gstat stand-alone, URL below).
x  
gstat object to print

fill.all  
logical; if TRUE, fill all of the direct variogram and, depending on the value of fill.cross also all cross variogram model slots in g with the given variogram model

fill.cross  
logical; if TRUE, fill all of the cross variograms, if FALSE fill only all direct variogram model slots in g with the given variogram model (only if fill.all is used)

variance  
character; variance function to transform to non-stationary covariances; "identity" does not transform, other options are "mu" (Poisson) and "mu(1-mu)" (binomial)

weights  
numeric vector; if present, covariates are present, and variograms are missing weights are passed to OLS prediction routines resulting in WLS; if variograms are given, weights should be 1/variance, where variance specifies location-specific measurement error; see references section below

merge  
either character vector of length 2, indicating two ids that share a common mean; the more general gstat merging of any two coefficients across variables is obtained when a list is passed, with each element a character vector of length 4, in the form c("id1",1,"id2",2). This merges the first parameter for variable id1 to the second of variable id2.

degree  
order of trend surface in the location, between 0 and 3

vdist  
logical; if TRUE, instead of Euclidian distance variogram distance is used for selecting the nmax nearest neighbours, after observations within distance maxdist (Euclidian/geographic) have been pre-selected

lambda  
test feature; doesn’t do anything (yet)

...  
arguments that are passed to the printing of variogram models only

Details

to print the full contents of the object g returned, use as.list(g) or print.default(g)

Value

an object of class gstat, which inherits from list. Its components are:

data  
list; each element is a list with the formula, locations, data, nvars, beta, etc., for a variable

model  
list; each element contains a variogram model; names are those of the elements of data; cross variograms have names of the pairs of data elements, separated by a . (e.g.: var1.var2)

set  
list; named list, corresponding to set name=value; gstat commands (look up the set command in the gstat manual for a full list)
Note

The function currently copies the data objects into the gstat object, so this may become a large object. I would like to copy only the name of the data frame, but could not get this to work. Any help is appreciated.

Subsetting (see examples) is done using the id’s of the variables, or using numeric subsets. Subsetted gstat objects only contain cross variograms if (i) the original gstat object contained them and (ii) the order of the subset indexes increases, numerically, or given the order they have in the gstat object.

The merge item may seem obscure. Still, for colocated cokriging, it is needed. See texts by Goovaerts, Wackernagel, Chiles and Delfiner, or look for standardised ordinary kriging in the 1992 Deutsch and Journel or Isaaks and Srivastava. In these cases, two variables share a common mean parameter. Gstat generalises this case: any two variables may share any of the regression coefficients; allowing for instance analysis of covariance models, when variograms were left out (see e.g. R. Christensen’s “Plane answers” book on linear models). The tests directory of the package contains examples in file merge.R. There is also demo(pcb) which merges slopes across years, but with year-dependent intercept.

Author(s)

Edzer Pebesma

References


for kriging with known, varying measurement errors (weights), see e.g. Delhomme, J.P. Kriging in the hydrosciences. Advances in Water Resources, 1(5):251-266, 1978; see also the section Kriging with known measurement errors in the gstat user's manual. http://www.gstat.org/

See Also

predict, krige

Examples

library(sp)
data(meuse)
coordinates(meuse) = ~x+y
# let's do some manual fitting of two direct variograms and a cross variogram
g <- gstat(id = "ln.zinc", formula = log(zinc)-1, data = meuse)
g <- gstat(g, id = "ln.lead", formula = log(lead)-1, data = meuse)
# examine variograms and cross variogram:
plot(variogram(g))
# enter direct variograms:
g <- gstat(g, id = "ln.zinc", model = vgm(.55, "Sph", 900, .05))
g <- gstat(g, id = "ln.lead", model = vgm(.55, "Sph", 900, .05))
# enter cross variogram:
g <- gstat(g, id = c("ln.zinc", "ln.lead"), model = vgm(.47, "Sph", 900, .03))
# examine fit:
Produce h-scatterplot

Description

Produces h-scatterplots, where point pairs having specific separation distances are plotted. This function is a wrapper around xyplot.

Usage

hscat(formula, data, breaks, pch = 3, cex = .6, mirror = FALSE, 
variogram.alpha = 0, as.table = TRUE,...)

Arguments

formula specifies the dependent variable

data data where the variable in formula is resolved

breaks distance class boundaries
pch: plotting symbol

cex: plotting symbol size

mirror: logical; duplicate all points mirrored along x=y? (note that correlations are those of the points plotted)

variogram.alpha: parameter to be passed as alpha parameter to variogram; if alpha is specified it will only affect xyplot by being passed through ...

as.table: logical; if TRUE, panels plot top-to-bottom

... parameters, passed to variogram and xyplot

Value

an object of class trellis; normally the h scatter plot

Note

Data pairs are plotted once, so the h-scatterplot are not symmetric.

Author(s)

Edzer Pebesma

References

http://www.gstat.org/


Examples

library(sp)
data(meuse)
coordinates(meuse) = ~x+y
hscat(log(zinc)-1, meuse, c(0, 80, 120, 250, 500, 1000))

Image Gridded Coordinates in Data Frame

Description

Image gridded data, held in a data frame, keeping the right aspect ratio for axes, and the right cell shape

Usage

## S3 method for class 'data.frame'
image(x, zcol = 3, xcol = 1, ycol = 2, asp = 1, ...)
xyz2img(xyz, zcol = 3, xcol = 1, ycol = 2, tolerance = 10 * .Machine$double.eps)
Arguments

- **x**: data frame (or matrix) with x-coordinate, y-coordinate, and z-coordinate in its columns
- **zcol**: column number or name of z-variable
- **xcol**: column number or name of x-coordinate
- **ycol**: column number or name of y-coordinate
- **asp**: aspect ratio for the x and y axes
- ... arguments, passed to image.default
- **xyz**: data frame (same as x)
- **tolerance**: maximum allowed deviation for coordinates from being exactly on a regularly spaced grid

Value

`image.data.frame` plots an image from gridded data, organized in arbitrary order, in a data frame. It uses `xyz2img` and `image.default` for this. In the S-Plus version, `xyz2img` tries to make an image object with a size such that it will plot with an equal aspect ratio; for the R version, `image.data.frame` uses the `asp=1` argument to guarantee this.

`xyz2img` returns a list with components: `z`, a matrix containing the z-values; `x`, the increasing coordinates of the rows of `z`; `y`, the increasing coordinates of the columns of `z`. This list is suitable input to `image.default`.

Note

I wrote this function before I found out about `levelplot`, a Lattice/Trellis function that lets you control the aspect ratio by the `aspect` argument, and that automatically draws a legend, and therefore I now prefer levelplot over image. Plotting points on a levelplots is probably done with providing a panel function and using `lpoints`.

(for S-Plus only – ) it is hard (if not impossible) to get exactly right cell shapes (e.g., square for a square grid) without altering the size of the plotting region, but this function tries hard to do so by extending the image to plot in either x- or y-direction. The larger the grid, the better the approximation. Geographically correct images can be obtained by modifying `par("pin")`. Read the examples, image a 2 x 2 grid, and play with `par("pin")` if you want to learn more about this.

Author(s)

Edzer Pebesma

Examples

```r
library(sp)
data(meuse)
data(meuse.grid)
g <- gstat(formula=log(zinc)~1,locations=~x+y,data=meuse,model=vgm(1,"Exp",300))
x <- predict(g, meuse.grid)
image(x, 4, main="kriging variance and data points")
points(meuse$x, meuse$y, pch = "+")
```
The jura data set from Pierre Goovaerts’ book (see references below). It contains four dataframes: prediction.dat, validation.dat and transect.dat and juragrid.dat, and three dataframes with consistently coded land use and rock type factors, as well as geographic coordinates. The examples below show how to transform these into spatial (sp) objects in a local coordinate system and in geographic coordinates, and how to transform to metric coordinate reference systems.

Usage

data(jura)

Format

The dataframes prediction.dat and validation.dat contain the following fields:

- Xloc  X coordinate, local grid km
- Yloc  Y coordinate, local grid km
- Landuse  see book and below
- Rock  see book and below
- Cd  mg cadmium kg^-1 topsoil
- Co  mg cobalt kg^-1 topsoil
- Cr  mg chromium kg^-1 topsoil
- Cu  mg copper kg^-1 topsoil
- Ni  mg nickel kg^-1 topsoil
- Pb  mg lead kg^-1 topsoil
- Zn  mg zinc kg^-1 topsoil

The dataframe juragrid.dat only has the first four fields. In addition the dataframes jura.pred, jura.val and jura.grid also have inserted third and fourth fields giving geographic coordinates:

- long  Longitude, WGS84 datum
- lat  Latitude, WGS84 datum

Note

The points data sets were obtained from http://home.comcast.net/~pgoovaerts/book.html, which seems to be no longer available; the grid data were kindly provided by Pierre Goovaerts.

The following codes were used to convert prediction.dat and validation.dat to jura.pred and jura.val (see examples below):

Land uses: 1: Forest, 2: Pasture (Weide(land), Wiese, Grasland), 3: Meadow (Wiese, Flur, Matte, Anger), 4: Tillage (Ackerland, bestelltes Land)

Points 22 and 100 in the validation set (validation.dat[c(22,100),]) seem not to lie exactly on the grid originally intended, but are kept as such to be consistent with the book.

Georeferencing was based on two control points in the Swiss grid system shown as Figure 1 of Atteia et al. (see above) and further points digitized on the tentatively georeferenced scanned map. RMSE 2.4 m. Location of points in the field was less precise.

Author(s)

Data preparation by David Rossiter (dgr2@cornell.edu) and Edzer Pebesma; georeferencing by David Rossiter

References


Atteia, O., Dubois, J.-P., Webster, R., 1994, Geostatistical analysis of soil contamination in the Swiss Jura: Environmental Pollution 86, 315-327

Webster, R., Atteia, O., Dubois, J.-P., 1994, Coregionalization of trace metals in the soil in the Swiss Jura: European Journal of Soil Science 45, 205-218

Examples

data(jura)
summary(prediction.dat)
summary(validation.dat)
summary(transect.dat)
summary(juragrid.dat)

# the following commands were used to create objects with factors instead of the integer codes for Landuse and Rock:
## Not run:
jura.pred = prediction.dat
jura.val = validation.dat
jura.grid = juragrid.dat

jura.pred$Landuse = factor(prediction.dat$Landuse, labels=levels(juragrid.dat$Landuse))
jura.pred$Rock = factor(prediction.dat$Rock, labels=levels(juragrid.dat$Rock))
jura.val$Landuse = factor(validation.dat$Landuse, labels=levels(juragrid.dat$Landuse))
jura.val$Rock = factor(validation.dat$Rock, labels=levels(juragrid.dat$Rock))

## End(Not run)

# the following commands convert data.frame objects into spatial (sp) objects in the local grid:
require(sp)
coordinates(jura.pred) = ~Xloc+Yloc
coordinates(jura.val) = ~Xloc+Yloc
coordinates(jura.grid) = ~Xloc+Yloc
gridded(jura.grid) = TRUE

# the following commands convert the data.frame objects into spatial (sp) objects
# in WGS84 geographic coordinates
# example is given only for jura.pred, do the same for jura.val and jura.grid
# EPSG codes can be found by searching make_EPSG()
jura.pred <- as.data.frame(jura.pred)
coordinates(jura.pred) = ~ long + lat
proj4string(jura.pred) = CRS("+init=epsg:4326")
# display in Google Earth
## Not run:
if (require(maptools)) {
  kmlPoints(jura.pred,
  kmlfile="JuraPred.kml",
  kmlname="Jura Prediction Points",name=row.names(jura.pred@data),
  description=paste(jura.pred$Landuse, jura.pred$Rock, sep="/"))
}
## End(Not run)

if (require(rgdal)) {
  # transform to UTM 32N
  jura.pred.utm32n = spTransform(jura.pred,
  CRS("+init=epsg:32632"))
  coordnames(jura.pred.utm32n) = c("E","N")

  # transform to Swiss grid system CH1903 / LV03
  jura.pred.ch = spTransform(jura.pred,
  CRS("+init=epsg:21781"))
  coordnames(jura.pred.ch) = c("X","Y")
}

## End(Not run)

krige

Simple, Ordinary or Universal, global or local, Point or Block Kriging, or simulation.

Description

Function for simple, ordinary or universal kriging (sometimes called external drift kriging), kriging in a local neighbourhood, point kriging or kriging of block mean values (rectangular or irregular blocks), and conditional (Gaussian or indicator) simulation equivalents for all kriging varieties, and function for inverse distance weighted interpolation. For multivariable prediction, see gstat and predict.
Usage

krige(formula, locations, ...)  
krige.locations(formula, locations, data, newdata, model, ..., beta, nmax = Inf, nmin = 0, omax = 0, maxdist = Inf, block, nsim = 0, indicators = FALSE, na.action = na.pass, debug.level = 1)  
krige.spatial(formula, locations, newdata, model, ..., beta, nmax = Inf, nmin = 0, omax = 0, maxdist = Inf, block, nsim = 0, indicators = FALSE, na.action = na.pass, debug.level = 1)  
krige0(formula, data, newdata, model, beta, y, ..., computeVar = FALSE, fullCovariance = FALSE)  
idw(formula, locations, ...)  
idw.locations(formula, locations, data, newdata, nmax = Inf, nmin = 0, omax = 0, maxdist = Inf, block, na.action = na.pass, idp = 2.0, debug.level = 1)  
idw.spatial(formula, locations, newdata, nmax = Inf, nmin = 0, omax = 0, maxdist = Inf, block = numeric(0), na.action = na.pass, idp = 2.0, debug.level = 1)  
idw0(formula, data, newdata, y, idp = 2.0)

Arguments

formula  
formula that defines the dependent variable as a linear model of independent variables; suppose the dependent variable has name z, for ordinary and simple kriging use the formula z~1; for simple kriging also define beta (see below); for universal kriging, suppose z is linearly dependent on x and y, use the formula z~x+y

locations  
object of class Spatial or sf, or (deprecated) formula defines the spatial data locations (coordinates) such as ~x+y

data  
data frame: should contain the dependent variable, independent variables, and coordinates, should be missing if locations contains data.

newdata  
object of class Spatial, sf or stars with prediction/simulation locations; should contain attributes with the independent variables (if present).

model  
variogram model of dependent variable (or its residuals), defined by a call to vgm or fit.variogram; for krige0 also a user-supplied covariance function is allowed (see example below)

beta  
for simple kriging (and simulation based on simple kriging): vector with the trend coefficients (including intercept); if no independent variables are defined the model only contains an intercept and beta should be the simple kriging mean

nmax  
for local kriging: the number of nearest observations that should be used for a kriging prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, all observations are used

nmin  
for local kriging: if the number of nearest observations within distance maxdist is less than nmin, a missing value will be generated; see maxdist

omax  
see gstat
maxdist  for local kriging: only observations within a distance of maxdist from the prediction location are used for prediction or simulation; if combined with nmax, both criteria apply

block  block size; a vector with 1, 2 or 3 values containing the size of a rectangular in x-, y- and z-dimension respectively (0 if not set), or a data frame with 1, 2 or 3 columns, containing the points that discretize the block in the x-, y- and z-dimension to define irregular blocks relative to (0,0) or (0,0,0)—see also the details section of predict. By default, predictions or simulations refer to the support of the data values.

nsim  integer; if set to a non-zero value, conditional simulation is used instead of kriging interpolation. For this, sequential Gaussian or indicator simulation is used (depending on the value of indicators), following a single random path through the data.

indicators  logical, only relevant if nsim is non-zero; if TRUE, use indicator simulation; else use Gaussian simulation

na.action  function determining what should be done with missing values in 'newdata'. The default is to predict 'NA'. Missing values in coordinates and predictors are both dealt with.

debug.level  debug level, passed to predict; use -1 to see progress in percentage, and 0 to suppress all printed information

...  for krige: arguments that will be passed to gstat; for krige0: arguments that will be passe to model

idp  numeric; specify the inverse distance weighting power

y  matrix; to krige multiple fields in a single step, pass data as columns of matrix y. This will ignore the value of the response in formula.

computeVar  logical; if TRUE, prediction variances will be returned

fullCovariance  logical; if FALSE a vector with prediction variances will be returned, if TRUE the full covariance matrix of all predictions will be returned

Details

Function krige is a simple wrapper method around gstat and predict for univariate kriging prediction and conditional simulation methods available in gstat. For multivariate prediction or simulation, or for other interpolation methods provided by gstat (such as inverse distance weighted interpolation or trend surface interpolation) use the functions gstat and predict directly.

Function idw performs just as krige without a model being passed, but allows direct specification of the inverse distance weighting power. Don't use with predictors in the formula.

For further details, see predict.

Value

if locations is not a formula, object of the same class as newdata (deriving from Spatial); else a data frame containing the coordinates of newdata. Attributes columns contain prediction and prediction variance (in case of kriging) or the abs(nsim) columns of the conditional Gaussian or indicator simulations
krige0 and idw0 are alternative functions with reduced functionality and larger memory requirements; they return numeric vectors (or matrices, in case of multiple dependent) with predicted values only; in case computeVar is TRUE, a list with elements pred and var is returned, containing predictions, and (co)variances (depending on argument fullCovariance).

Methods

- formula = "formula", locations = "formula" locations specifies which coordinates in data refer to spatial coordinates
- formula = "formula", locations = "Spatial" Object locations knows about its own spatial locations
- formula = "formula", locations = "NULL" used in case of unconditional simulations; newdata needs to be of class Spatial

Note

Daniel G. Krige is a South African scientist who was a mining engineer when he first used generalised least squares prediction with spatial covariances in the 50's. George Matheron coined the term kriging in the 60's for the action of doing this, although very similar approaches had been taken in the field of meteorology. Beside being Krige's name, I consider "krige" to be to "kriging" what "predict" is to "prediction".

Author(s)

Edzer Pebesma

References


http://www.gstat.org/


See Also

gstat, predict

Examples

library(sp)
data(meuse)
coordinates(meuse) = ~x+y
data(meuse.grid)
gridded(meuse.grid) = ~x+y
m <- vgm(.59, "Sph", 874, .04)
# ordinary kriging:
x <- krige(log(zinc)~1, meuse, meuse.grid, model = m)
spplot(x["var1.pred"], main = "ordinary kriging predictions")
spplot(x["var1.var"], main = "ordinary kriging variance")
# simple kriging:
x <- krige(log(zinc)~1, meuse, meuse.grid, model = m, beta = 5.9)
# residual variogram:
m <- vgm(.4, "Sph", 954, .06)
# universal block kriging:
x <- krige(log(zinc)~x+y, meuse, meuse.grid, model = m, block = c(40,40))
spplot(x["var1.pred"], main = "universal kriging predictions")

# kriging0, using user-defined covariance function and multiple responses in y:
# exponential variogram with range 500, defined as covariance function:
v = function(x, y = x) { exp(-spDists(coordinates(x),coordinates(y))/500) }
# kriging two variables in a single pass (using 1 covariance model):
y = cbind(meuse$zinc,meuse$copper,meuse$lead,meuse$cadmium)
x <- kriging0(log(zinc)~1, meuse, meuse.grid, v, y = y)
meuse.grid$zinc = x[,1]
spplot(meuse.grid["zinc"], main = "zinc")
meuse.grid$copper = x[,2]
spplot(meuse.grid["copper"], main = "copper")

# the following has NOTHING to do with kriging, but --
# return the median of the nearest 11 observations:
x = kriging(zinc~1, meuse, meuse.grid, set = list(method = "med"), nmax = 11)
# get 25% and 75%-percentiles of nearest 11 obs, as prediction and variance:
x = kriging(zinc~1, meuse, meuse.grid, nmax = 11, set = list(method = "med", quantile = 0.25))
# get diversity (# of different values) and mode from 11 nearest observations:
x = kriging(zinc~1, meuse, meuse.grid, nmax = 11, set = list(method = "div"))

krigeb.cv
(co)kriging cross validation, n-fold or leave-one-out

Description
Cross validation functions for simple, ordinary or universal point (co)kriging, kriging in a local neighbourhood.

Usage
gstat.cv(object, nfold, remove.all = FALSE, verbose = interactive(),
all.residuals = FALSE, ...)
krigeb.cv(formula, locations, ...)
krigeb.cv.locations(formula, locations, data, model = NULL, ..., beta = NULL,
nmax = Inf, nmin = 0, maxdist = Inf, nfold = nrow(data),
verbose = interactive(), debug.level = 0)
krigeb.cv.spatial(formula, locations, model = NULL, ..., beta = NULL,
nmax = Inf, nmin = 0, maxdist = Inf, nfold = nrow(locations),
verbose = interactive(), debug.level = 0)
Arguments

- **object**: object of class gstat; see function gstat
- **nfold**: integer; if larger than 1, then apply n-fold cross validation; if nfold equals nrow(data) (the default), apply leave-one-out cross validation; if set to e.g. 5, five-fold cross validation is done. To specify the folds, pass an integer vector of length nrow(data) with fold indexes.
- **remove.all**: logical; if TRUE, remove observations at cross validation locations not only for the first, but for all subsequent variables as well
- **verbose**: logical; if FALSE, progress bar is suppressed
- **all.residuals**: logical; if TRUE, residuals for all variables are returned instead of for the first variable only
- **...**: other arguments that will be passed to predict in case of gstat.cv, or to gstat in case of krige.cv
- **formula**: formula that defines the dependent variable as a linear model of independent variables; suppose the dependent variable has name z, for ordinary and simple kriging use the formula z~1; for simple kriging also define beta (see below); for universal kriging, suppose z is linearly dependent on x and y, use the formula z~x+y
- **locations**: data object deriving from class Spatial or sf
- **data**: data frame (deprecated); should contain the dependent variable, independent variables, and coordinates; only to be provided if locations is a formula
- **model**: variogram model of dependent variable (or its residuals), defined by a call to vgm or fit.variogram
- **beta**: only for simple kriging (and simulation based on simple kriging); vector with the trend coefficients (including intercept); if no independent variables are defined the model only contains an intercept and this should be the simple kriging mean
- **nmax**: for local kriging: the number of nearest observations that should be used for a kriging prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, all observations are used
- **nmin**: for local kriging: if the number of nearest observations within distance maxdist is less than nmin, a missing value will be generated; see maxdist
- **maxdist**: for local kriging: only observations within a distance of maxdist from the prediction location are used for prediction or simulation; if combined with nmax, both criteria apply
- **debug.level**: print debugging information; 0 suppresses debug information

Details

Leave-one-out cross validation (LOOCV) visits a data point, and predicts the value at that location by leaving out the observed value, and proceeds with the next data point. (The observed value is left out because kriging would otherwise predict the value itself.) N-fold cross validation makes a partitions the data set in N parts. For all observation in a part, predictions are made based on the remaining N-1 parts; this is repeated for each of the N parts. N-fold cross validation may be faster than LOOCV.
Value
data frame containing the coordinates of data or those of the first variable in object, and columns of prediction and prediction variance of cross validated data points, observed values, residuals, zscore (residual divided by kriging standard error), and fold.

If all.residuals is true, a data frame with residuals for all variables is returned, without coordinates.

Methods

formula = "formula", locations = "formula" locations specifies which coordinates in data refer to spatial coordinates

formula = "formula", locations = "Spatial" Object locations knows about its own spatial locations

Note

Leave-one-out cross validation seems to be much faster in plain (stand-alone) gstat, apparently quite a bit of the effort is spent moving data around from R to gstat.

Author(s)

Edzer Pebesma

References

http://www.gstat.org/

See Also

krige, gstat, predict

Examples

library(sp)
data(meuse)
coordinates(meuse) <- ~x+y
m <- vgm(.59, "Sph", 874, .04)
# five-fold cross validation:
x <- krige.cv(log(zinc) ~ 1, meuse, m, nmax = 40, nfold=5)
bubble(x, "residual", main = "log(zinc): 5-fold CV residuals")

# multivariable; thanks to M. Rufino:
meuse.g <- gstat(id = "zn", formula = log(zinc) ~ 1, data = meuse)
meuse.g <- gstat(meuse.g, "cu", log(copper) ~ 1, meuse)
meuse.g <- gstat(meuse.g, model = vgm(1, "Sph", 900, 1), fill.all = TRUE)
x <- variogram(meuse.g, cutoff = 1000)
meuse.fit = fit.lmc(x, meuse.g)
out = gstat.cv(meuse.fit, nmax = 40, nfold = 5)
summary(out)
out = gstat.cv(meuse.fit, nmax = 40, nfold = c(rep(1,100), rep(2,55)))
summary(out)
# mean error, ideally 0:
mean(out$residual)
# MSPE, ideally small
mean(out$residual^2)
# Mean square normalized error, ideally close to 1
mean(out$zscore^2)
# correlation observed and predicted, ideally 1
cor(out$observed, out$observed - out$residual)
# correlation predicted and residual, ideally 0
cor(out$observed - out$residual, out$residual)

**krigeSimCE**

*Simulation based on circulant embedding*

**Description**

Simulating a conditional/unconditional Gaussian random field via kriging and circulant embedding

**Usage**

krigeSimCE(formula, data, newdata, model, n = 1, ext = 2)

**Arguments**

- `formula`: the formula of the kriging predictor
- `data`: spatial data frame that conditions the simulation
- `newdata`: locations in space where the Gaussian random field shall be simulated
- `model`: a vgm model that defines the spatial covariance structure
- `n`: number of simulations
- `ext`: extension factor of the circulant embedding, defaults to 2

**Value**

A spatial data frame as defined in `newdata` with `n` simulations.

**Author(s)**

Benedikt Graeler

**References**

krigeST

Ordinary global Spatio-Temporal Kriging

Description

Function for ordinary global and local and trans Gaussian spatio-temporal kriging on point support

Usage

krigeST(formula, data, newdata, modelList, beta, y, ..., nmax = Inf, stAni = NULL, computeVar = FALSE, fullCovariance = FALSE, bufferNmax=2, progress=TRUE)
krigeSTTg(formula, data, newdata, modelList, y, nmax=Inf, stAni=NULL, bufferNmax=2, progress=TRUE, lambda = 0)

Arguments

formula formula that defines the dependent variable as a linear model of independent variables; suppose the dependent variable has name z, for ordinary and simple kriging use the formula z~1; for simple kriging also define beta (see below); for universal kriging, suppose z is linearly dependent on x and y, use the formula z~x+y
data ST object: should contain the dependent variable and independent variables.
newdata ST object with prediction/simulation locations in space and time; should contain attribute columns with the independent variables (if present).
modelList object of class StVariogramModel, created by vgmST - see below or the function vgmAreaST for area-to-point kriging. For the general kriging case: a list with named elements: space, time and/or joint depending on the spatio-temporal covariance family, and an entry stModel. Currently implemented families that may be used for stModel are separable, productSum, metric, sumMetric and simpleSumMetric. See the examples section in fit.StVariogram or variogramSurface for details on how to define spatio-temporal covariance models. krigeST will look for a “temporal unit” attribute in the provided modellist in order to adjust the temporal scales.
y matrix; to krig multiple fields in a single step, pass data as columns of matrix y. This will ignore the value of the response in formula.
beta The (known) mean for simple kriging.

See Also

krigeSTSimTB

Examples

# see demo('circEmbeddingMeuse')
**krigeST**

- `nmax` The maximum number of neighbouring locations for a spatio-temporal local neighbourhood.

- `stAni` A spatio-temporal anisotropy scaling assuming a metric spatio-temporal space. Used only for the selection of the closest neighbours. This scaling needs only to be provided in case the model does not have a stAni parameter, or if a different one should be used for the neighbourhood selection. Mind the correct spatial unit. Currently, no coordinate conversion is made for the neighbourhood selection (i.e. Lat and Lon require a spatio-temporal anisotropy scaling in degrees per second).

- `computeVar` Logical; if TRUE, prediction variances will be returned.

- `fullCovariance` Logical; if FALSE a vector with prediction variances will be returned, if TRUE the full covariance matrix of all predictions will be returned.

- `bufferNmax` Factor with which nmax is multiplied for an extended search radius (default=2). Set to 1 for no extension of the search radius.

- `progress` Whether a progress bar shall be printed for local spatio-temporal kriging; default=TRUE.

- `lambda` The value of lambda used in the box-cox transformation.

**Details**

Function `krigeST` is a R implementation of the kriging function from `gstat` using spatio-temporal covariance models following the implementation of `krige0`. Function `krigeST` offers some particular methods for ordinary spatio-temporal (ST) kriging. In particular, it does not support block kriging or kriging in a distance-based neighbourhood, and does not provide simulation.

**Value**

An object of the same class as `newdata` (deriving from `ST`). Attributes columns contain prediction and prediction variance.

**Author(s)**

Edzer Pebesma, Benedikt Graeler

**References**


http://www.gstat.org/

See Also

krige0, gstat, predict, krigetg

Examples

library(sp)
library(spacetime)
sumMetricVgm <- vgmST("sumMetric",
    space = vgm(4.4, "Lin", 196.6, 3),
    time = vgm(2.2, "Lin", 1.1, 2),
    joint = vgm(34.6, "Exp", 136.6, 12),
    stAni = 51.7)

data(air)
suppressWarnings(proj4string(stations) <- CRS(proj4string(stations)))
rural = STFDF(stations, dates, data.frame(PM10 = as.vector(air)))

rr <- rural[,"2005-06-01/2005-06-03"]
rr <- as(rr,"STDF")
x1 <- seq(from=6,to=15,by=1)
x2 <- seq(from=48,to=55,by=1)

DE_gridded <- SpatialPoints(cbind(rep(x1,length(x2)), rep(x2,each=length(x1))),
    proj4string=CRS(proj4string(rr@sp)))
gridded(DE_gridded) <- TRUE

DE_pred <- STF(sp=as(DE_gridded,"SpatialPoints"), time=rr@time)
DE_kriged <- krigeST(PM10~1, data=rr, newdata=DE_pred,
    modelList=sumMetricVgm)
gridded(DE_kriged@sp) <- TRUE
stplot(DE_kriged)

krigeSTSimTB  conditional/unconditional spatio-temporal simulation

Description

conditional/unconditional spatio-temporal simulation based on turning bands

Usage

krigeSTSimTB(formula, data, newdata, modelList, nsim, progress = TRUE,
    nLyrs = 500, tGrid = NULL, sGrid = NULL, ceExt = 2, nmax = Inf)

Arguments

formula  the formula of the kriging predictor
data  conditioning data
newdata locations in space and time where the simulation is carried out
modelList the spatio-temporal variogram (from vgmST) defining the spatio-temporal covariance structure of the simulated Gaussian random field
nsim number of simulations
progress boolean; whether the progress should be shown in progress bar
nLyrs number of layers used in the turning bands approach (default = 500)
tGrid optional explicit temporal gridding that shall be used
sGrid optional explicit spatial gridding that shall be used
cEExt expansion in the circulant embedding, defaults to 2
nmax number of nearest neighbours that shall be used, defaults to 'Inf' meaning all available points are used

Value
a spatio-temporal data frame with nSim simulations

Author(s)
Benedikt Graeler

References
Turning bands

Turning layers

See Also
krigeSimCE

Examples
# see demo('circEmbeddingMeuse')
krigeTg

### Description

TransGaussian (ordinary) kriging function using Box-Cox transforms

### Usage

```r
krigeTg(formula, locations, newdata, model = NULL, ..., 
        nmax = Inf, nmin = 0, maxdist = Inf, block = numeric(0), 
        nsim = 0, na.action = na.pass, debug.level = 1, 
        lambda = 1.0)
```

### Arguments

- **formula**: formula that defines the dependent variable as a linear model of independent variables; suppose the dependent variable has name z, for ordinary and use a formula like z~1; the dependent variable should be NOT transformed.
- **locations**: object of class `Spatial`, with observations
- **newdata**: Spatial object with prediction/simulation locations; the coordinates should have names as defined in `locations`
- **model**: variogram model of the TRANSFORMED dependent variable, see `vgm`, or `fit.variogram`
- **nmax**: for local kriging: the number of nearest observations that should be used for a kriging prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, all observations are used
- **nmin**: for local kriging: if the number of nearest observations within distance `maxdist` is less than `nmin`, a missing value will be generated; see `maxdist`
- **maxdist**: for local kriging: only observations within a distance of `maxdist` from the prediction location are used for prediction or simulation; if combined with `nmax`, both criteria apply
- **block**: does not function correctly, afaik
- **nsim**: does not function correctly, afaik
- **na.action**: function determining what should be done with missing values in `newdata`. The default is to predict 'NA'. Missing values in coordinates and predictors are both dealt with.
- **lambda**: value for the Box-Cox transform
- **debug.level**: debug level, passed to `predict`; use -1 to see progress in percentage, and 0 to suppress all printed information
- **...**: other arguments that will be passed to `gstat`
Function \texttt{krigeTg} uses transGaussian kriging as explained in \url{http://www.math.umd.edu/~bnk/bak/Splus/kriging.html}.

As it uses the \texttt{R/gstat} krig function to derive everything, it needs in addition to ordinary kriging on the transformed scale a simple kriging step to find \( m \) from the difference between the OK and SK prediction variance, and a kriging/BLUE estimation step to obtain the estimate of \( \mu \).

For further details, see \texttt{krige} and \texttt{predict}.

**Value**

an \texttt{SpatialPointsDataFrame} object containing the fields: \( m \) for the \( m \) (Lagrange) parameter for each location; \texttt{var1SK.pred} the \( C^{-1}c_0 \) correction obtained by \texttt{muhat} for the mean estimate at each location; \texttt{var1SK.var} the simple kriging variance; \texttt{var1.pred} the OK prediction on the transformed scale; \texttt{var1.var} the OK kriging variance on the transformed scale; \texttt{var1TG.pred} the transGaussian kriging predictor; \texttt{var1TG.var} the transGaussian kriging variance, obtained by \( \phi'(\hat{\mu}, \lambda)^2 \sigma^2_{OK} \).

**Author(s)**

Edzer Pebesma

**References**


\url{http://www.gstat.org/}

**See Also**

\texttt{gstat}, \texttt{predict}

**Examples**

```r
library(sp)
data(meuse)
coordinates(meuse) = ~x+y
data(meuse.grid)
gridded(meuse.grid) = ~x+y
v = vgm(1, "Exp", 300)
x1 = krigeTg(zinc~1,meuse,meuse.grid,v, lambda=1) # no transform
x2 = krige(zinc~1,meuse,meuse.grid,v)
summary(x2$var1.var-x1$var1TG.var)
summary(x2$var1.pred-x1$var1TG.pred)
lambda = -0.25
m = fit.variogram(variogram((zinc^lambda-1)/lambda ~ 1,meuse), vgm(1, "Exp", 300))
x = krigeTg(zinc~1,meuse,meuse.grid,m,lambda=-.25)
spplot(x["var1TG.pred"], col.regions=bpy.colors())
summary(meuse$zinc)
summary(x$var1TG.pred)
```
map.to.lev rearrange data frame for plotting with levelplot

Description
rearrange data frame for plotting with levelplot

Usage
map.to.lev(data, xcol = 1, ycol = 2, zcol = c(3, 4), ns = names(data)[zcol])

Arguments
data data frame, e.g. output from kriged or predict
xcol x-coordinate column number
ycol y-coordinate column number
zcol z-coordinate column number range
ns names of the set of z-columns to be viewed

Value
data frame with the following elements:
x x-coordinate for each row
y y-coordinate for each row
z column vector with each of the elements in columns zcol of data stacked
name factor; name of each of the stacked z columns

See Also
image.data.frame, kriged; for examples see predict; levelplot in package lattice.

meuse.all Meuse river data set – original, full data set

Description
This data set gives locations and top soil heavy metal concentrations (ppm), along with a number of soil and landscape variables, collected in a flood plain of the river Meuse, near the village Stein. Heavy metal concentrations are bulk sampled from an area of approximately 15 m x 15 m.

Usage
data(meuse.all)
Format

This data frame contains the following columns:

- **sample**: sample number
- **x**: a numeric vector; x-coordinate (m) in RDM (Dutch topographical map coordinates)
- **y**: a numeric vector; y-coordinate (m) in RDM (Dutch topographical map coordinates)
- **cadmium**: topsoil cadmium concentration, ppm.; note that zero cadmium values in the original data set have been shifted to 0.2 (half the lowest non-zero value)
- **copper**: topsoil copper concentration, ppm.
- **lead**: topsoil lead concentration, ppm.
- **zinc**: topsoil zinc concentration, ppm.
- **elev**: relative elevation
- **om**: organic matter, as percentage
- **ffreq**: flooding frequency class
- **soil**: soil type
- **lime**: lime class
- **landuse**: landuse class
- **dist.m**: distance to river Meuse (metres), as obtained during the field survey
- **in.pit**: logical; indicates whether this is a sample taken in a pit
- **in.meuse155**: logical; indicates whether the sample is part of the meuse (i.e., filtered) data set; in addition to the samples in a pit, an sample (139) with outlying zinc content was removed
- **in.BMcD**: logical; indicates whether the sample is used as part of the subset of 98 points in the various interpolation examples of Burrough & McDonnell

Note

sample refers to original sample number. Eight samples were left out because they were not indicative for the metal content of the soil. They were taken in an old pit. One sample contains an outlying zinc value, which was also discarded for the meuse (155) data set.

Author(s)

The actual field data were collected by Ruud van Rijn and Mathieu Rikken; data compiled for R by Edzer Pebesma

References


http://www.gstat.org/

See Also

meuse.alt
meuse.alt

Meuse river altitude data set

Description

This data set gives a point set with altitudes, digitized from the 1:10,000 topographical map of the Netherlands.

Usage

data(meuse.alt)

Format

This data frame contains the following columns:

- `x` a numeric vector; x-coordinate (m) in RDM (Dutch topographical map coordinates)
- `y` a numeric vector; y-coordinate (m) in RDM (Dutch topographical map coordinates)
- `alt` altitude in m. above NAP (Dutch zero for sea level)

References

http://www.gstat.org/

See Also

meuse.all

Examples

data(meuse.alt)
library(lattice)
xyplot(y~x, meuse.alt, aspect = "iso")
ncp.grid

Grid for the NCP, the Dutch part of the North Sea

Description

Gridded data for the NCP (Nederlands Continentaal Plat, the Dutch part of the North Sea), for a 5 km x 5 km grid; stored as data.frame.

Usage

data(ncp.grid)

Format

This data frame contains the following columns:

- x  x-coordinate, UTM zone 31
- y  y-coordinate, UTM zone 31
- depth  sea water depth, m.
- coast  distance to the coast of the Netherlands, in km.
- area  identifier for administrative sub-areas

Author(s)

Dutch National Institute for Coastal and Marine Management (RIKZ); data compiled for R by Edzer Pebesma

See Also

fulmar

Examples

data(ncp.grid)
summary(ncp.grid)
ossfim

Kriging standard errors as function of grid spacing and block size

Description

Calculate, for a given variogram model, ordinary block kriging standard errors as a function of sampling spaces and block sizes

Usage

ossfim(spacings = 1:5, block.sizes = 1:5, model, nmax = 25, debug = 0)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>spacings</td>
<td>range of grid (data) spacings to be used</td>
</tr>
<tr>
<td>block.sizes</td>
<td>range of block sizes to be used</td>
</tr>
<tr>
<td>model</td>
<td>variogram model, output of \texttt{vgm}</td>
</tr>
<tr>
<td>nmax</td>
<td>set the kriging neighbourhood size</td>
</tr>
<tr>
<td>debug</td>
<td>debug level; set to 32 to see a lot of output</td>
</tr>
</tbody>
</table>

Value

data frame with columns \texttt{spacing} (the grid spacing), \texttt{block.size} (the block size), and \texttt{kriging.se} (block kriging standard error)

Note

The idea is old, simple, but still of value. If you want to map a variable with a given accuracy, you will have to sample it. Suppose the variogram of the variable is known. Given a regular sampling scheme, the kriging standard error decreases when either (i) the data spacing is smaller, or (ii) predictions are made for larger blocks. This function helps quantifying this relationship. Ossfim probably refers to “optimal sampling scheme for isarithmic mapping”.

Author(s)

Edzer Pebesma

References


## oxford

### See Also
- kriges

### Examples

```r
## Not run:
x <- ossfim(1:15,1:15, model = vgm(1,"Exp",15))
library(lattice)
levelplot(kriging.se~spacing+block.size, x,
  main = "Ossfim results, variogram 1 Exp(15)"
)
## End(Not run)
# if you wonder about the decrease in the upper left corner of the graph,
# try the above with nmax set to 100, or perhaps 200.
```

---

### oxford

#### Oxford soil samples

#### Description

Data: 126 soil augerings on a 100 x 100m square grid, with 6 columns and 21 rows. Grid is oriented with long axis North-north-west to South-south-east Origin of grid is South-south-east point, 100m outside grid.

Original data are part of a soil survey carried out by P.A. Burrough in 1967. The survey area is located on the chalk downlands on the Berkshire Downs in Oxfordshire, UK. Three soil profile units were recognised on the shallow Rendzina soils; these are Ia - very shallow, grey calcareous soils less than 40cm deep over chalk; Ct - shallow to moderately deep, grey-brown calcareous soils on calcareous colluvium, and Cr: deep, moderately acid, red-brown clayey soils. These soil profile classes were registered at every augering.

In addition, an independent landscape soil map was made by interpolating soil boundaries between these soil types, using information from the changes in landform. Because the soil varies over short distances, this field mapping caused some soil borings to receive a different classification from the classification based on the point data.

Also registered at each auger point were the site elevation (m), the depth to solid chalk rock (in cm) and the depth to lime in cm. Also, the percent clay content, the Munsell colour components of VALUE and CHROMA, and the lime content of the soil (as tested using HCl) were recorded for the top two soil layers (0-20cm and 20-40cm).

Samples of topsoil taken as a bulk sample within a circle of radius 2.5m around each sample point were used for the laboratory determination of Mg (ppm), OM %, CEC as mequ/100g air dry soil, pH, P as ppm and K (ppm).

#### Usage

```r
data(oxford)
```
Format

This data frame contains the following columns:

- **PROFILE** profile number
- **XCOORD** x-coordinate, field, non-projected
- **YCOORD** y-coordinate, field, non-projected
- **ELEV** elevation, m.
- **PROFCLASS** soil class, obtained by classifying the soil profile at the sample site
- **MAPCLASS** soil class, obtained by looking up the site location in the soil map
- **VAL1** Munsell colour component VALUE, 0-20 cm
- **CHR1** Munsell colour component CHROMA, 20-40 cm
- **LIME1** Lime content (tested using HCl), 0-20 cm
- **VAL2** Munsell colour component VALUE, 0-20 cm
- **CHR2** Munsell colour component CHROMA, 20-40 cm
- **LIME2** Lime content (tested using HCl), 20-40 cm
- **DEPTHCM** soil depth, cm
- **DEP2LIME** depth to lime, cm
- **PCLAY1** percentage clay, 0-20 cm
- **PCLAY2** percentage clay, 20-40 cm
- **MG1** Magnesium content (ppm), 0-20 cm
- **OM1** organic matter (%), 0-20 cm
- **CEC1** CES as mequ/100g air dry soil, 0-20 cm
- **PH1** pH, 0-20 cm
- **PHOS1** Phosphorous, 0-20 cm, ppm
- **POT1** K (potassium), 0-20 cm, ppm

Note

- oxford.jpg, in the gstat package external directory (see example below), shows an image of the soil map for the region

Author(s)

P.A. Burrough; compiled for R by Edzer Pebesma

References


Examples

data(oxford)
summary(oxford)
# open the following file with a jpg viewer:
system.file("external/oxford.jpg", package="gstat")
Description

PCB138 measurements in sediment at the NCP, which is the Dutch part of the North Sea

Usage

data(pcb)

Format

This data frame contains the following columns:

- **year**: measurement year
- **x**: x-coordinate; UTM zone 31
- **y**: y-coordinate; UTM zone 31
- **coast**: distance to coast of the Netherlands, in km.
- **depth**: sea water depth, m.
- **PCB138**: PCB-138, measured on the sediment fraction smaller than 63 \( \mu \)m, in \( \mu g/kg \) dry matter; BUT SEE NOTE BELOW
- **yf**: year; as factor

Note

A note of caution: The PCB-138 data are provided only to be able to re-run the analysis done in Pebesma and Duin (2004; see references below). If you want to use these data for comparison with PCB measurements elsewhere, or if you want to compare them to regulation standards, or want to use these data for any other purpose, you should first contact basisinfodesk@rikz.rws.minvenw.nl. The reason for this is that several normalisations were carried out that are not reported here, nor in the paper below.

References


See Also

ncp.grid
Examples

data(pcb)
library(lattice)
xyplot(y~x|as.factor(yf), pcb, aspect = "iso")
# demo(pcb)

plot.gstatVariogram  
Plot a sample variogram, and possibly a fitted model

Description

Creates a variogram plot

Usage

## S3 method for class 'gstatVariogram'
plot(x, model = NULL, ylim, xlim, xlab = "distance",
     ylab = attr(x, "what"), panel = vgm.panel.xyplot, multipanel = TRUE,
     plot.numbers = FALSE, scales, ids = x$id, group.id = TRUE, skip,
     layout, ...)
## S3 method for class 'variogramMap'
plot(x, np = FALSE, skip, threshold, ...)
## S3 method for class 'StVariogram'
plot(x, model = NULL, ..., col = bpy.colors(), xlab, ylab,
     map = TRUE, convertMonths = FALSE, as.table = TRUE, wireframe = FALSE,
     diff = FALSE, all = FALSE)

Arguments

x  
object obtained from the method variogram, possibly containing directional or
cross variograms, space-time variograms and variogram model information

model  
in case of a single variogram: a variogram model, as obtained from vgm or
fit.variogram, to be drawn as a line in the variogram plot; in case of a set of
variograms and cross variograms: a list with variogram models; in the spatio-
temporal case, a single or a list of spatio-temporal models that will be plotted
next to each other for visual comparison.

ylim  
numeric; vector of length 2, limits of the y-axis

xlim  
numeric; vector of length 2, limits of the x-axis

xlab  
character; x-axis label

ylab  
character; y-axis label

panel  
panel function

multipanel  
logical; if TRUE, directional variograms are plotted in different panels, if FALSE,
directional variograms are plotted in the same graph, using color, colored lines
and symbols to distinguish them
plot.gstatVariogram

plot.numbers logical or numeric; if TRUE, plot number of point pairs next to each plotted semivariance symbol, if FALSE these are omitted. If numeric, TRUE is assumed and the value is passed as the relative distance to be used between symbols and numeric text values (default 0.03).

scales optional argument that will be passed to xyplot in case of the plotting of variograms and cross variograms; use the value list(relation = "same") if y-axes need to share scales

ids ids of the data variables and variable pairs

group.id logical; control for directional multivariate variograms: if TRUE, panels divide direction and colors indicate variables (ids), if FALSE panels divide variables/variable pairs and colors indicate direction

skip logical; can be used to arrange panels, see xyplot

layout integer vector; can be used to set panel layout: c(ncol,nrow)

np logical (only for plotting variogram maps); if TRUE, plot number of point pairs, if FALSE plot semivariances

threshold semivariogram map values based on fewer point pairs than threshold will not be plotted

... any arguments that will be passed to the panel plotting functions (such as auto.key in examples below)

col colors to use

map logical; if TRUE, plot space-time variogram map

convertMonths logical; if TRUE, yearmon time lags will be unit converted and plotted as (integer) months, and no longer match the numeric representation of yearmon, which has years as unit

as.table controls the plotting order for multiple panels, see xyplot for details.

wireframe logical; if TRUE, produce a wireframe plot

diff logical; if TRUE, plot difference between model and sample variogram; ignores all.

all logical; if TRUE, plot sample and model variogram(s) in single wireframes.

Details

Please note that in the spatio-temporal case the levelplot and wireframe plots use the spatial distances averaged for each time lag avgDist. For strongly varying spatial locations over time, please check the distance columns dist and avgDist of the spatio-temporal sample variogram. The lattice::cloud function is one option to plot irregular 3D data.

Value

returns (or plots) the variogram plot

Note

currently, plotting models and/or point pair numbers is not supported when a variogram is both directional and multivariable; also, three-dimensional directional variograms will probably not be displayed correctly.
Author(s)

Edzer Pebesma

References

http://www.gstat.org

See Also

variogram, fit.variogram, vgm variogramLine,

Examples

library(sp)
data(meuse)
coordinates(meuse) = ~x+y
vgm1 <- variogram(log(zinc)-1, meuse)
plot(vgm1)
model.1 <- fit.variogram(vgm1,vgm(1,"Sph",300,1))
plot(vgm1, model=model.1)
plot(vgm1, plot.numbers = TRUE, pch = "+")
vgm2 <- variogram(log(zinc)-1, meuse, alpha=c(0,45,90,135))
plot(vgm2)
# the following demonstrates plotting of directional models:
model.2 <- vgm(.59,"Sph",926,.06,anis=c(0,0.3))
plot(vgm2, model=model.2)

g = gstat(NULL, "zinc < 200", I(zinc<200)-1, meuse)
g = gstat(g, "zinc < 400", I(zinc<400)-1, meuse)
g = gstat(g, "zinc < 800", I(zinc<800)-1, meuse)
# calculate multivariable, directional variogram:
v = variogram(g, alpha=c(0,45,90,135))
plot(v, group.id = FALSE, auto.key = TRUE) # id and id pairs panels
plot(v, group.id = TRUE, auto.key = TRUE) # direction panels

# variogram maps:
plot(variogram(g, cutoff=1000, width=100, map=TRUE),
     main = "(cross) semivariance maps")
plot(variogram(g, cutoff=1000, width=100, map=TRUE), np=TRUE,
     main = "number of point pairs")

plot.pointPairs

Plot a point pairs, identified from a variogram cloud

Description

Plot a point pairs, identified from a variogram cloud
**Usage**

```
## S3 method for class 'pointPairs'
plot(x, data, xcol = data$x, ycol = data$y, xlab = "x coordinate",
     ylab = "y coordinate", col.line = 2, line.pch = 0, main = "selected point pairs", ...)
```

**Arguments**

- **x**: object of class "pointPairs", obtained from the function `plot.variogramCloud`, containing point pair indices
- **data**: data frame to which the indices refer (from which the variogram cloud was calculated)
- **xcol**: numeric vector with x-coordinates of data
- **ycol**: numeric vector with y-coordinates of data
- **xlab**: x-axis label
- **ylab**: y-axis label
- **col.line**: color for lines connecting points
- **line.pch**: if non-zero, symbols are also plotted at the middle of line segments, to mark lines too short to be visible on the plot; the color used is `col.line`; the value passed to this argument will be used as plotting symbol (pch)
- **main**: title of plot
- **...**: arguments, further passed to `xyplot`

**Value**

plots the data locations, with lines connecting the point pairs identified (and refered to by indices in) x

**Author(s)**

Edzer Pebesma

**References**

[http://www.gstat.org](http://www.gstat.org)

**See Also**

`plot.variogramCloud`

**Examples**

```r
### The following requires interaction, and is therefore outcommented
#data(meuse)
#coordinates(meuse) = ~x+y
#vgm1 <- variogram(log(zinc)~1, meuse, cloud = TRUE)
#pp <- plot(vgm1, id = TRUE)
### Identify the point pairs
#plot(pp, data = meuse) # meuse has x and y as coordinates
```
plot.viariogramCloud  

Plot and Identify Data Pairs on Sample Variogram Cloud

Description
Plot a sample variogram cloud, possibly with identification of individual point pairs

Usage
## S3 method for class 'variogramCloud'
plot(x, identify = FALSE, digitize = FALSE, xlim, ylim, xlab, ylab,
     keep = FALSE, ...)

Arguments

x  
object of class variogramCloud

identify  
logical; if TRUE, the plot allows identification of a series of individual point pairs that correspond to individual variogram cloud points (use left mouse button to select; right mouse button ends)

digitize  
logical; if TRUE, select point pairs by digitizing a region with the mouse (left mouse button adds a point, right mouse button ends)

xlim  
limits of x-axis

ylim  
limits of y-axis

xlab  
x axis label

ylab  
y axis label

keep  
logical; if TRUE and identify is TRUE, the labels identified and their position are kept and glued to object x, which is returned. Subsequent calls to plot this object will now have the labels shown, e.g. to plot to hardcopy

...  
parameters that are passed through to plot.gstatVariogram (in case of identify = FALSE) or to plot (in case of identify = TRUE)

Value

If identify or digitize is TRUE, a data frame of class pointPairs with in its rows the point pairs identified (pairs of row numbers in the original data set); if identify is F, a plot of the variogram cloud, which uses plot.gstatVariogram

If in addition to identify, keep is also TRUE, an object of class variogramCloud is returned, having attached to it attributes "sel" and "text", which will be used in subsequent calls to plot.viariogramCloud with identify set to FALSE, to plot the text previously identified.

If in addition to digitize, keep is also TRUE, an object of class variogramCloud is returned, having attached to it attribute "poly", which will be used in subsequent calls to plot.viariogramCloud with digitize set to FALSE, to plot the digitized line.

In both of the keep = TRUE cases, the attribute ppairs of class pointPairs is present, containing the point pairs identified.
predict

Author(s)
Edzer Pebesma

References
http://www.gstat.org/

See Also
variogram, plot.gstatVariogram, plot.pointPairs, identify, locator

Examples

library(sp)
data(meuse)
coordinates(meuse) = ~x+y
plot(variogram(log(zinc)~1, meuse, cloud=TRUE))
## commands that require interaction:
# x <- variogram(log(zinc)~1, loc=~x+y, data=meuse, cloud=TRUE)
# plot(plot(x, identify = TRUE), meuse)
# plot(plot(x, digitize = TRUE), meuse)

---

Description

The function provides the following prediction methods: simple, ordinary, and universal kriging, simple, ordinary, and universal cokriging, point- or block-kriging, and conditional simulation equivalents for each of the kriging methods.

Usage

## S3 method for class 'gstat'
predict(object, newdata, block = numeric(0), nsim = 0,
indicators = FALSE, BLUE = FALSE, debug.level = 1, mask,
na.action = na.pass, sps.args = list(n = 500, type = "regular",
offset = c(.5, .5)), ...)

Arguments

object object of class gstat, see gstat and krig
newdata data frame with prediction/simulation locations; should contain columns with the independent variables (if present) and the coordinates with names as defined in locations; or: polygons, see below
block: block size; a vector with 1, 2 or 3 values containing the size of a rectangular in x-, y- and z-dimension respectively (0 if not set), or a data frame with 1, 2 or 3 columns, containing the points that discretize the block in the x-, y- and z-dimension to define irregular blocks relative to (0,0) or (0,0,0)—see also the details section below. By default, predictions or simulations refer to the support of the data values.

nsim: integer; if set to a non-zero value, conditional simulation is used instead of kriging interpolation. For this, sequential Gaussian or indicator simulation is used (depending on the value of indicators), following a single random path through the data.

indicators: logical; only relevant if nsim is non-zero; if TRUE, use indicator simulation, else use Gaussian simulation.

BLUE: logical; if TRUE return the BLUE trend estimates only, if FALSE return the BLUP predictions (kriging).

debug.level: integer; set gstat internal debug level, see below for useful values. If set to -1 (or any negative value), a progress counter is printed.

mask: not supported anymore – use na.action; logical or numerical vector; pattern with valid values in newdata (marked as TRUE, non-zero, or non-NA); if mask is specified, the returned data frame will have the same number and order of rows in newdata, and masked rows will be filled with NA's.

na.action: function determining what should be done with missing values in 'newdata'. The default is to predict 'NA'. Missing values in coordinates and predictors are both dealt with.

sps.args: when newdata is of class SpatialPolygons or SpatialPolygonsDataFrame this argument list gets passed to spsample to control the discretizing of polygons

Details

When a non-stationary (i.e., non-constant) mean is used, both for simulation and prediction purposes the variogram model defined should be that of the residual process, not that of the raw observations.

For irregular block kriging, coordinates should discretize the area relative to (0), (0,0) or (0,0,0); the coordinates in newdata should give the centroids around which the block should be located. So, suppose the block is discretized by points (3,3) (3,5) (5,5) and (5,3), we should pass point (4,4) in newdata and pass points (-1,-1) (-1,1) (1,1) (1,-1) to the block argument. Although passing the uncentered block and (0,0) as newdata may work for global neighbourhoods, neighbourhood selection is always done relative to the centroid values in newdata.

If newdata is of class SpatialPolygons or SpatialPolygonsDataFrame, then the block average for each of the polygons or polygon sets is calculated, using spsample to discretize the polygon(s). Argument sps.args controls the parameters used for spsample. The "location" with respect to which neighbourhood selection is done is for each polygon the SpatialPolygons polygon label point; if you use local neighbourhoods you should check out where these points are—it may be well outside the polygon itself.

The algorithm used by gstat for simulation random fields is the sequential simulation algorithm. This algorithm scales well to large or very large fields (e.g., more than $10^6$ nodes). Its power
lies in using only data and simulated values in a local neighbourhood to approximate the conditional distribution at that location, see \( n_{\text{max}} \) in \texttt{krige} and \texttt{gstat}. The larger \( n_{\text{max}} \), the better the approximation, the smaller \( n_{\text{max}} \), the faster the simulation process. For selecting the nearest \( n_{\text{max}} \) data or previously simulated points, \texttt{gstat} uses a bucket PR quadtree neighbourhood search algorithm; see the reference below.

For sequential Gaussian or indicator simulations, a random path through the simulation locations is taken, which is usually done for sequential simulations. The reason for this is that the local approximation of the conditional distribution, using only the \( n_{\text{max}} \) nearest observed (or simulated) values may cause spurious correlations when a regular path would be followed. Following a single path through the locations, \texttt{gstat} reuses the expensive results (neighbourhood selection and solution to the kriging equations) for each of the subsequent simulations when multiple realisations are requested. You may expect a considerable speed gain in simulating 1000 fields in a single call to \texttt{predict}, compared to 1000 calls, each for simulating a single field.

The random number generator used for generating simulations is the native random number generator of the environment (\texttt{R}, \texttt{S}); fixing randomness by setting the random number seed with \texttt{set.seed()} works.

When mean coefficients are not supplied, they are generated as well from their conditional distribution (assuming multivariate normal, using the generalized least squares BLUE estimate and its estimation covariance); for a reference to the algorithm used see Abrahamsen and Benth, Math. Geol. 33(6), page 742 and leave out all constraints.

Memory requirements for sequential simulation: let \( n \) be the product of the number of variables, the number of simulation locations, and the number of simulations required in a single call, the \texttt{gstat} C function \texttt{gstat\_predict} requires a table of size \( n \times 12 \) bytes to pass the simulations back to \texttt{R}, before it can free \( n \times 4 \) bytes. Hopefully, \texttt{R} does not have to duplicate the remaining \( n \times 8 \) bytes when the coordinates are added as columns, and when the resulting matrix is coerced to a \texttt{data.frame}.

Useful values for \texttt{debug.level}: 0: suppress any output except warning and error messages; 1: normal output (default): short data report, program action and mode, program progress in \%, total execution time; 2: print the value of all global variables, all files read and written, and include source file name and line number in error messages; 4: print OLS and WLS fit diagnostics; 8: print all data after reading them; 16: print the neighbourhood selection for each prediction location; 32: print (generalised) covariance matrices, design matrices, solutions, kriging weights, etc.; 64: print variogram fit diagnostics (number of iterations and variogram model in each iteration step) and order relation violations (indicator kriging values before and after order relation correction); 512: print block (or area) discretization data for each prediction location. To combine settings, sum their respective values. Negative values for \texttt{debug.level} are equal to positive, but cause the progress counter to work.

For data with longitude/latitude coordinates (checked by \texttt{is.projected}), \texttt{gstat} uses great circle distances in km to compute spatial distances. The user should make sure that the semivariogram model used is positive definite on a sphere.

**Value**

a data frame containing the coordinates of \texttt{newdata}, and columns of prediction and prediction variance (in case of kriging) or the columns of the conditional Gaussian or indicator simulations
### Examples

```r
# generate 5 conditional simulations
library(sp)
data(meuse)
coordinates(meuse) = ~x+y
v <- variogram(log(zinc)|1, meuse)
m <- fit.variogram(v, vgm(1, "Sph", 300, 1))
plot(v, model = m)
set.seed(131)
data(meuse.grid)
grided(meuse.grid) = ~x+y
sim <- krige(formula = log(zinc)|1, meuse, meuse.grid, model = m, nmax = 10, beta = 5.9, nsim = 5) # for speed -- 10 is too small!!
# show all 5 simulation
spplot(sim)
```

```r
# calculate generalised least squares residuals w.r.t. constant trend:
g <- gstat(NULL, "log.zinc", log(zinc)|1, meuse, model = m)
blue0 <- predict(g, newdata = meuse, BLUE = TRUE)
blue0$blue.res <- log(meuse$zinc) - blue0$log.zinc.pred
bubble(blue0, zcol = "blue.res", main = "GLS residuals w.r.t. constant")
```

```r
# calculate generalised least squares residuals w.r.t. linear trend:
m <- fit.variogram(variogram(log(zinc)|sqrt(dist.m), meuse),
vgm(1, "Sph", 300, 1))
g <- gstat(NULL, "log.zinc", log(zinc)|sqrt(dist.m), meuse, model = m)
blue1 <- predict(g, meuse, BLUE = TRUE)
blue1$blue.res <- log(meuse$zinc) - blue1$log.zinc.pred
bubble(blue1, zcol = "blue.res", main = "GLS residuals w.r.t. linear trend")
```

```r
# unconditional simulation on a 100 x 100 grid
xy <- expand.grid(1:100, 1:100)
names(xy) <- c("x","y")
grided(xy) = ~x+y
g.dummy <- gstat(formula = z~1, dummy = TRUE, beta = 0, model = vgm(1,"Exp",15), nmax = 10) # for speed -- 10 is too small!!
```
progress

yy <- predict(g.dummy, xy, nsim = 4)
# show one realisation:
spplot(yy[1])
# show all four:
spplot(yy)

progress  Get or set progress indicator

Description
Get or set progress indicator

Usage
get_gstat_progress()
set_gstat_progress(value)

Arguments
value  logical

Value
return the logical value indicating whether progress bars should be given

Author(s)
Edzer Pebesma

Examples
set_gstat_progress(FALSE)
get_gstat_progress()
show.vgms

Plot Variogram Model Functions

Description

Creates a trellis plot for a range of variogram models, possibly with nugget; and optionally a set of Matern models with varying smoothness.

Usage

show.vgms(min = 1e-12 * max, max = 3, n = 50, sill = 1, range = 1,
models = as.character(vgm()$short[c(1:17)]), nugget = 0, kappa.range = 0.5,
plot = TRUE, ..., as.groups = FALSE)

Arguments

min numeric; start distance value for semivariance calculation beyond the first point at exactly zero
max numeric; maximum distance for semivariance calculation and plotting
n integer; number of points to calculate distance values
sill numeric; (partial) sill(s) of the variogram model
range numeric; range(s) of the variogram model
models character; variogram model(s) to be plotted
nugget numeric; nugget component(s) for variogram models
kappa.range numeric; if this is a vector with more than one element, only a range of Matern models is plotted with these kappa values
plot logical; if TRUE, a plot is returned with the models specified; if FALSE, the data prepared for this plot is returned
... passed on to the call to xyplot
as.groups logical; if TRUE, different models are plotted with different lines in a single panel, else, in one panel per model

Value

returns a (Trellis) plot of the variogram models requested; see examples. I do currently have strong doubts about the “correctness” of the “Hol” model. The “Spl” model does seem to need a very large range value (larger than the study area?) to be of some value.

If plot is FALSE, a data frame with the data prepared to plot is being returned.

Note

the min argument is supplied because the variogram function may be discontinuous at distance zero, surely when a positive nugget is present.
sic2004

Description

The text below was copied from the original sic2004 event, which is no longer online available.

The variable used in the SIC 2004 exercise is natural ambient radioactivity measured in Germany.
The data, provided kindly by the German Federal Office for Radiation Protection (BfS), are gamma
dose rates reported by means of the national automatic monitoring network (IMIS).

In the frame of SIC2004, a rectangular area was used to select 1008 monitoring stations (from a total
of around 2000 stations). For these 1008 stations, 11 days of measurements have been randomly
selected during the last 12 months and the average daily dose rates calculated for each day. Hence,
we ended up having 11 data sets.

Prior information (sic.train): 10 data sets of 200 points that are identical for what concerns the loca-
tions of the monitoring stations have been prepared. These locations have been randomly selected
(see Figure 1). These data sets differ only by their Z values since each set corresponds to 1 day
of measurement made during the last 14 months. No information will be provided on the date of
measurement. These 10 data sets (10 days of measurements) can be used as prior information to
tune the parameters of the mapping algorithms. No other information will be provided about these
sets. Participants are free of course to gather more information about the variable in the literature
and so on.
The 200 monitoring stations above were randomly taken from a larger set of 1008 stations. The remaining 808 monitoring stations have a topology given in sic.pred. Participants to SIC2004 will have to estimate the values of the variable taken at these 808 locations.

The SIC2004 data (sic.val, variable dayx): The exercise consists in using 200 measurements made on a 11th day (THE data of the exercise) to estimate the values observed at the remaining 808 locations (hence the question marks as symbols in the maps shown in Figure 3). These measurements will be provided only during two weeks (15th of September until 1st of October 2004) on a web page restricted to the participants. The true values observed at these 808 locations will be released only at the end of the exercise to allow participants to write their manuscripts (sic.test, variables dayx and joker).

In addition, a joker data set was released (sic.val, variable joker), which contains an anomaly. The anomaly was generated by a simulation model, and does not represent measured levels.

Usage

data(sic2004) #

Format

The data frames contain the following columns:

- **record** this integer value is the number (unique value) of the monitoring station chosen by us.
- **x** X-coordinate of the monitoring station indicated in meters
- **y** Y-coordinate of the monitoring station indicated in meters
- **day01** mean gamma dose rate measured during 24 hours, at day01. Units are nanoSieverts/hour
- **day02** same, for day 02
- **day03** ...
- **day04** ...
- **day05** ...
- **day06** ...
- **day07** ...
- **day08** ...
- **day09** ...
- **day10** ...
- **dayx** the data observed at the 11-th day
- **joker** the joker data set, containing an anomaly not present in the training data

Note

the data set sic.grid provides a set of points on a regular grid (almost 10000 points) covering the area; this is convenient for interpolation; see the function makegrid in package sp.

The coordinates have been projected around a point located in the South West of Germany. Hence, a few coordinates have negative values as can be guessed from the Figures below.
sic97  Spatial Interpolation Comparison 1997 data set: Swiss Rainfall

Description
The text below is copied from the data item at ai-geostats, https://wiki.52north.org/bin/view/AI_GEOSTATS/WebHome

Usage
data(sic97) #

Format
The data frames contain the following columns:

- **ID**  this integer value is the number (unique value) of the monitoring station
- **rainfall**  rainfall amount, in 10th of mm

Note
See the pdf that accompanies the original file for a description of the data. The .dxf file with the Swiss border is not included here.
**Author(s)**

Gregoire Dubois and others.

**References**

https://wiki.52north.org/bin/view/AI_GEOSTATS/WebHome

**Examples**

```r
data(sic97)
image(demstd)
points(sic_full, pch=1)
points(sic_obs, pch=3)
```

---

**spplot.vcov**

*Plot map matrix of prediction error variances and covariances*

**Description**

Plot map matrix of prediction error variances and covariances

**Usage**

```r
spplot.vcov(x, ...)
```

**Arguments**

- `x` Object of class SpatialPixelsDataFrame or SpatialGridDataFrame, resulting from a krige call with multiple variables (cokriging

- `...` remaining arguments passed to spplot

**Value**

The plotted object, of class trellis; see spplot in package *sp*.

**Author(s)**

Edzer Pebesma
Südliche Tullnerfeld data set

Description

The Südliche Tullnerfeld is a part of the Danube river basin in central Lower Austria and due to its homogeneous aquifer well suited for a model-oriented geostatistical analysis. It contains 36 official water quality measurement stations, which are irregularly spread over the region.

Usage

data(tull)

Format

The data frames contain the following columns:

- x: X location in meter
- y: Y location in meter
- S411: Station name
- S429: Station name
- S849: Station name
- S854: Station name
- S1502: Station name
- S1584: Station name
- S1591: Station name
- S2046: Station name
- S2047: Station name
- S2048: Station name
- S2049: Station name
- S2051: Station name
- S2052: Station name
- S2053: Station name
- S2054: Station name
- S2055: Station name
- S2057: Station name
- S2058: Station name
- S2059: Station name
- S2060: Station name
- S2061: Station name
Note

This data set was obtained on May 6, 2008 from http://www.ifas.jku.at/e5361/index_ger.html. The author of the book that uses it is found at: http://www.ifas.jku.at/e2571/e2604/index_ger.html

References

Werner G. Müller, Collecting Spatial Data, 3rd edition. Springer Verlag, Heidelberg, 2007

Examples

data(tull)

# TULLNREG = read.csv("TULLNREG.csv")

# I modified tulln36des.csv, such that the first line only contained: x,y
# resulting in row.names that reflect the station ID, as in
# tull36 = read.csv("tulln36des.csv")

# Chlorid92 was read & converted by:
#Chlorid92=read.csv("Chlorid92.csv")
#Chlorid92$Datum = as.POSIXct(strptime(Chlorid92$Datum, "%d.%m.%y"))

summary(tull36)
summary(TULLNREG)
summary(Chlorid92)

# stack & join data to x,y,Date,Chloride form:
c1.st = stack(Chlorid92[-1])
names(cl.st) = c("Chloride", "Station")
cl.st$Date = rep(Chlorid92$Datum, length(names(Chlorid92))-1)
cl.st$x = tull36[match(cl.st[,"Station"], row.names(tull36)), "x"]
cl.st$y = tull36[match(cl.st[,"Station"], row.names(tull36)), "y"]
# library(lattice)
# xyplot(Chloride~Date|Station, cl.st)
# xyplot(y~x|Date, cl.st, asp="iso", layout=c(16,11))
summary(cl.st)
plot(TULLNREG, pch=3, asp=1)
points(y~x, cl.st, pch=16)

---

**Variogram**

*Calculate Sample or Residual Variogram or Variogram Cloud*

**Description**

Calculates the sample variogram from data, or in case of a linear model is given, for the residuals, with options for directional, robust, and pooled variogram, and for irregular distance intervals.

In case spatio-temporal data is provided, the function `variogramST` is called with a different set of parameters.

**Usage**

```r
## S3 method for class 'gstat'
variogram(object, ...) 
## S3 method for class 'formula'
variogram(object, locations = coordinates(data), data, ...)
## Default S3 method:
variogram(object, locations, X, cutoff, width = cutoff/15,
          alpha = 0, beta = 0, tol.hor = 90/length(alpha), tol.ver =
          90/length(beta), cressie = FALSE, dX = numeric(0), boundaries =
          numeric(0), cloud = FALSE, trend.beta = NULL, debug.level = 1,
          cross = TRUE, grid, map = FALSE, g = NULL, ..., projected = TRUE,
          lambda = 1.0, verbose = FALSE, covariogram = FALSE, PR = FALSE,
          pseudo = -1)
## S3 method for class 'gstatVariogram'
print(x, ...) 
## S3 method for class 'variogramCloud'
print(x, ...)
```

**Arguments**

- `object`: object of class gstat; in this form, direct and cross (residual) variograms are calculated for all variables and variable pairs defined in object; in case of `variogram.formula`, formula defining the response vector and (possible) regressors, in case of absence of regressors, use e.g. `z~1`; in case of `variogram.default`: list with for each variable the vector with responses (should not be called directly)

---
data frame where the names in formula are to be found

locations
spatial data locations. For variogram.formula: a formula with only the coordinate variables in the right hand (explanatory variable) side e.g. ~x+y; see examples.

For variogram.default: list with coordinate matrices, each with the number of rows matching that of corresponding vectors in y; the number of columns should match the number of spatial dimensions spanned by the data (1 (x), 2 (x,y) or 3 (x,y,z)).

... any other arguments that will be passed to variogram.default (ignored)

X
(optional) list with for each variable the matrix with regressors/covariates; the number of rows should match that of the corresponding element in y, the number of columns equals the number of regressors (including intercept)

cutoff
spatial separation distance up to which point pairs are included in semivariance estimates; as a default, the length of the diagonal of the box spanning the data is divided by three.

width
the width of subsequent distance intervals into which data point pairs are grouped for semivariance estimates

alpha
direction in plane (x,y), in positive degrees clockwise from positive y (North): alpha=0 for direction North (increasing y), alpha=90 for direction East (increasing x); optional a vector of directions in (x,y)

beta
direction in z, in positive degrees up from the (x,y) plane; optional a vector of directions

tol.hor
horizontal tolerance angle in degrees

tol.ver
vertical tolerance angle in degrees

cressie
logical; if TRUE, use Cressie’s robust variogram estimate; if FALSE use the classical method of moments variogram estimate

dX
include a pair of data points $y(s_1),y(s_2)$ taken at locations $s_1$ and $s_2$ for sample variogram calculation only when $||x(s_1)-x(s_2)|| < dX$ with and $x(s_i)$ the vector with regressors at location $s_i$, and $||.||$ the 2-norm. This allows pooled estimation of within-strata variograms (use a factor variable as regressor, and dX=0.5), or variograms of (near-)replicates in a linear model (addressing point pairs having similar values for regressors variables)

boundaries
numerical vector with distance interval upper boundaries; values should be strictly increasing

cloud
logical; if TRUE, calculate the semivariogram cloud

trend.beta
vector with trend coefficients, in case they are known. By default, trend coefficients are estimated from the data.

debug.level
integer; set gstat internal debug level

cross
logical or character; if FALSE, no cross variograms are computed when object is of class gstat and has more than one variable; if TRUE, all direct and cross variograms are computed; if equal to "ST", direct and cross variograms are computed for all pairs involving the first (non-time lagged) variable; if equal to "ONLY", only cross variograms are computed (no direct variograms).
variogram

formula object of class `variogram` or `variogramCloud` to be printed
x object of class `variogram` or `variogramCloud` to be printed
grid grid parameters, if data are gridded (not to be called directly; this is filled automatically)
map logical; if TRUE, and `cutoff` and `width` are given, a variogram map is returned. This requires package sp. Alternatively, a map can be passed, of class `SpatialDataFrameGrid` (see sp docs)
g NULL or object of class `gstat`; may be used to pass settable parameters and/or variograms; see example
projected logical; if FALSE, data are assumed to be unprojected, meaning decimal longitude/latitude. For projected data, Euclidian distances are computed, for unprojected great circle distances (km). In `variogram.formula` or `variogram.gstat` for data deriving from class `Spatial`, projection is detected automatically using `is.projected`
lambda test feature; not working (yet)
verbose logical; print some progress indication
pseudo integer; use pseudo cross variogram for computing time-lagged spatial variograms? -1: find out from coordinates – if they are equal then yes, else no; 0: no; 1: yes.
covariogram logical; compute covariogram instead of variogram?
PR logical; compute pairwise relative variogram (does NOT check whether variable is strictly positive)

Value

If map is TRUE (or a map is passed), a grid map is returned containing the (cross) variogram map(s). See package sp.
In other cases, an object of class “gstatVariogram” with the following fields:

np the number of point pairs for this estimate; in case of a `variogramCloud` see below
dist the average distance of all point pairs considered for this estimate
gamma the actual sample variogram estimate
dir.hor the horizontal direction
dir.ver the vertical direction
id the combined id pair

If cloud is TRUE: an object of class `variogramCloud`, with the field `np` encoding the numbers of the point pair that contributed to a variogram cloud estimate, as follows. The first point is found by 1 + the integer division of `np` by the `.BigInt` attribute of the returned object, the second point by 1 + the remainder of that division. `as.data.frame.variogramCloud` returns no `np` field, but does the decoding into:

left for `variogramCloud`: data id (row number) of one of the data pair
right for `variogramCloud`: data id (row number) of the other data in the pair

In case of a spatio-temporal variogram is sought see `variogramST` for details.
Note

variogram.default should not be called by users directly, as it makes many assumptions about the organization of the data, that are not fully documented (but of course, can be understood from reading the source code of the other variogram methods).

Successfully setting gridded() <- TRUE may trigger a branch that will fail unless dx and dy are identical, and not merely similar to within machine epsilon.

Note

variogram.line is DEPRECATED; it is and was never meant as a variogram method, but works automatically as such by the R dispatch system. Use variogramLine instead.

Author(s)

Edzer Pebesma

References

http://www.gstat.org/

See Also

print.gstatVariogram, plot.gstatVariogram, plot.variogramCloud; for variogram models: vgm, to fit a variogram model to a sample variogram: fit.variogram variogramST for details on the spatio-temporal sample variogram.

Examples

library(sp)
data(meuse)
# no trend:
coordinates(meuse) = ~x+y
variogram(log(zinc)-1, meuse)
# residual variogram w.r.t. a linear trend:
variogram(log(zinc)-x+y, meuse)
# directional variogram:
variogram(log(zinc)-x+y, meuse, alpha=c(0,45,90,135))
variogram(log(zinc)-1, meuse, width=90, cutoff=1300)

# GLS residual variogram:
v = variogram(log(zinc)-x+y, meuse)
v.fit = fit.variogram(v, vgm(1, "Sph", 700, 1))
v.fit
set = list(gls=1)
v
g = gstat(NULL, "log-zinc", log(zinc)-x+y, meuse, model=v.fit, set = set)
variogram(g)

if (require(rgdal)) {
  proj4string(meuse) = CRS("+init=epsg:28992")
  meuse.ll = spTransform(meuse, CRS("+proj=longlat +datum=WGS84"))
  # variogram of unprojected data, using great-circle distances, returning km as units
  variogram(log(zinc) ~ 1, meuse.ll)
}

---

**variogramLine**

**Semivariance Values For a Given Variogram Model**

**Description**

Generates a semivariance values given a variogram model

**Usage**

```r
variogramLine(object, maxdist, n = 200, min = 1.0e-6 * maxdist,
dir = c(1,0,0), covariance = FALSE, ..., dist_vector, debug.level = 0)
```

**Arguments**

- **object**: variogram model for which we want semivariance function values
- **maxdist**: maximum distance for which we want semivariance values
- **n**: number of points
- **min**: minimum distance; a value slightly larger than zero is usually used to avoid the discontinuity at distance zero if a nugget component is present
- **dir**: direction vector: unit length vector pointing the direction in x (East-West), y (North-South) and z (Up-Down)
- **covariance**: logical; if TRUE return covariance values, otherwise return semivariance values
- **...**: ignored
- **dist_vector**: numeric vector or matrix with distance values
- **debug.level**: gstat internal debug level

**Value**

A data frame of dimension (n x 2), with columns distance and gamma (semivariances or covariances), or in case dist_vector is a matrix, a conforming matrix with semivariance/covariance values is returned.

**Note**

variogramLine is used to generate data for plotting a variogram model.
Author(s)
Edzer Pebesma

See Also
plot.gstatVariogram

Examples

```r
variogramLine(vgm(5, "Exp", 10, 5), 10, 10)
# anisotropic variogram, plotted in E-W direction:
variogramLine(vgm(1, "Sph", 10, anis=c(0,0.5)), 10, 10)
# anisotropic variogram, plotted in N-S direction:
variogramLine(vgm(1, "Sph", 10, anis=c(0,0.5)), 10, 10, dir=c(0,1,0))
variogramLine(vgm(1, "Sph", 10, anis=c(0,0.5)), dir=c(0,1,0), dist_vector = 0.5)
variogramLine(vgm(1, "Sph", 10, anis=c(0,0.5)), dir=c(0,1,0), dist_vector = c(0, 0.5, 0.75))
```

---

variogramST *Calculate Spatio-Temporal Sample Variogram*

Description

Calculates the sample variogram from spatio-temporal data.

Usage

```r
variogramST(formula, locations, data, ..., tlags = 0:15, cutoff,
width = cutoff/15, boundaries = seq(0, cutoff, width),
progress = interactive(), pseudo = TRUE, assumeRegular = FALSE,
na.omit = FALSE, cores = 1)
```

Arguments

- `formula` formula, specifying the dependent variable.
- `locations` A STFDF or STSDF containing the variable; kept for compatibility reasons with variogram, either locations or data must be provided.
- `data` A STFDF, STSDF or STIDF containing the variable.
- `...` any other arguments that will be passed to the underlying `variogram` function. In case of using data of type STIDF, the argument `tunit` is recommended (and only used in the case of STIDF) to set the temporal unit of the tlags. Additionally, `twindow` can be passed to control the temporal window used for temporal distance calculations. This builds on the property of xts being ordered and only the next `twindow` instances are considered. This avoids the need of huge temporal distance matrices. The default uses twice the number as the average difference goes into the temporal cutoff.
variogramST

tlags  integer; time lags to consider or in case data is of class STIDF the actual temporal boundaries with time unit given by tunit otherwise the same unit as diff on the index of the time slot will generate is assumed.
cutoff  spatial separation distance up to which point pairs are included in semivariance estimates; as a default, the length of the diagonal of the box spanning the data is divided by three.
width  the width of subsequent distance intervals into which data point pairs are grouped for semivariance estimates, by default the cutoff is divided into 15 equal lags.
boundaries  numerical vector with distance interval upper boundaries; values should be strictly increasing
progress  logical; if TRUE, show text progress bar
pseudo  integer; use pseudo cross variogram for computing time-lagged spatial variograms? -1: find out from coordinates – if they are equal then yes, else no; 0: no; 1: yes.
assumeRegular  logical; whether the time series should be assumed regular. The first time step is assumed to be representative for the whole series. Note, that temporal lags are considered by index, and no check is made whether pairs actually have the desired separating distance.
na.omit  shall all NA values in the spatio-temporal variogram be dropped? In case where complete rows or columns in the variogram consists of NA only, plot might produce a distorted picture.
cores  number of cores to use in parallel

Value

The spatio-temporal sample variogram contains besides the fields np, dist and gamma the spatio-temporal fields, timelag, spacelag and avgDist, the first of which indicates the time lag used, the second and third different spatial lags. spacelag is the midpoint in the spatial lag intervals as passed by the parameter boundaries, whereas avgDist is the average distance between the point pairs found in a distance interval over all temporal lags (i.e. the averages of the values dist per temporal lag.) To compute variograms for space lag Sh$ and time lag St$, the pseudo cross variogram $E(Z_i(s)-Z_i+t(s+h))^2$ is averaged over all time lagged observation sets $Z_i$ and $Z_i+t$ available (weighted by the number of pairs involved).

Author(s)

Edzer Pebesma, Benedikt Graeler

References

http://www.gstat.org/

See Also

plot.StVariogram, for variogram models: vgmST, to fit a spatio-temporal variogram model to a spatio-temporal sample variogram: fit.StVariogram

Examples

# The following spatio-temporal variogram has been calculated through
# vv = variogram(PM10~1, r5to10, width=20, cutoff = 200, tlags=0:5)
# in the vignette “st”.

data(vv)
str(vv)
plot(vv)

---

variogramSurface  Semivariance values for a given spatio-temporal variogram model

Description

Generates a surface of semivariance values given a spatio-temporal variogram model (one of separable, productSum, sumMetric, simpleSumMetric or metric)

Usage

variogramSurface(model, dist_grid, covariance = FALSE)

Arguments

model  A spatio-temporal variogram model generated through vgmST or fit.StVariogram.
dist_grid  A data.frame with two columns: spacelag and timelag.
covariance  Whether the covariance should be computed instead of the variogram (default: FALSE).

Value

A data.frame with columns spacelag, timelag and gamma.

Author(s)

Benedikt Graeler

See Also

See variogramLine for the spatial version and fit.StVariogram for the estimation of spatio-temporal variograms.
Examples

```r
separableModel <- vgmST("separable",
    space=vgm(0.86, "Exp", 476, 0.14),
    time =vgm( 1, "Exp", 3, 0),
    sill=113)

data(vv)

if(require(lattice)) {
    plot(vv, separableModel, wireframe=TRUE, all=TRUE)
}

# plotting of sample and model variogram
plot(vv, separableModel)
```

---

### vgm

*Generate, or Add to Variogram Model*

**Description**

Generates a variogram model, or adds to an existing model. `print.variogramModel` prints the essence of a variogram model.

**Usage**

```r
vgm(psill = NA, model, range = NA, nugget, add.to, anis, kappa = 0.5, ..., covtable, Err = 0)
```

## S3 method for class 'variogramModel'

```r
print(x, ...)
```

## S3 method for class 'variogramModel'

```r
plot(x, cutoff, ..., type = 'l')
```

```r
as.vgm.variomodel(m)
```

**Arguments**

- **psill**: (partial) sill of the variogram model component, or model: see Details
- **model**: model type, e.g. "Exp", "Sph", "Gau", "Mat". Calling `vgm()` without a model argument returns a data.frame with available models.
- **range**: range parameter of the variogram model component; in case of anisotropy: major range
- **kappa**: smoothness parameter for the Matern class of variogram models
- **nugget**: nugget component of the variogram (this basically adds a nugget component to the model); if missing, nugget component is omitted
- **add.to**: the variogram model to which we want to add a component (structure)
- **anis**: anisotropy parameters: see notes below
x a variogram model to print or plot
... arguments that will be passed to print, e.g. digits (see examples), or to
variogramLine for the plot method

covtable if model is Tab, instead of model parameters a one-dimensional covariance table
can be passed here. See covtable.R in tests directory, and example below.

Err numeric; if larger than zero, the measurement error variance component that will
not be included to the kriging equations, i.e. kriging will now smooth the process
Y instead of predict the measured Z, where Z=Y+e, and Err is the variance of e

m object of class variomodel, see geoR
cutoff maximum distance up to which variogram values are computed
type plot type

Details

If only the first argument (psill) is given a character value indicating a model, as in vgm("Sph"),
then this taken as a shorthand form of vgm(NA,"Sph",NA,NA), i.e. a spherical variogram with
nugget and unknown parameter values; see examples below. Read fit.variogram to find out how
NA variogram parameters are given initial values for a fitting a model, based on the sample variogram.
Package automap gives further options for automated variogram modelling.

Value

If a single model is passed, an object of class variogramModel extending data.frame.

In case a vector of models is passed, an object of class variogramModelList which is a list of
variogramModel objects.

When called without a model argument, a data.frame with available models is returned, having two
columns: short (abbreviated names, to be used as model argument: "Exp", "Sph" etc) and long
(with some description).

as.vgm.variomodel tries to convert an object of class variomodel (geoR) to vgm.

Note

Geometric anisotropy can be modelled for each individual simple model by giving two or five
anisotropy parameters, two for two-dimensional and five for three-dimensional data. In any case,
the range defined is the range in the direction of the strongest correlation, or the major range.
Anisotropy parameters define which direction this is (the main axis), and how much shorter the
range is in (the) direction(s) perpendicular to this main axis.

In two dimensions, two parameters define an anisotropy ellipse, say anis = c(30,0.5). The first
parameter, 30, refers to the main axis direction: it is the angle for the principal direction of continuity
(measured in degrees, clockwise from positive Y, i.e. North). The second parameter, 0.5, is the
anisotropy ratio, the ratio of the minor range to the major range (a value between 0 and 1). So, in
our example, if the range in the major direction (North-East) is 100, the range in the minor direction
(South-East) is 0.5 x 100 = 50.

In three dimensions, five values should be given in the form anis = c(p,q,r,s,t). Now, $p$ is
the angle for the principal direction of continuity (measured in degrees, clockwise from Y, in
direction of X), $q$ is the dip angle for the principal direction of continuity (measured in positive
degrees up from horizontal), $r$ is the third rotation angle to rotate the two minor directions around the principal direction defined by $p$ and $s$. A positive angle acts counter-clockwise while looking in the principal direction. Anisotropy ratios $s$ and $t$ are the ratios between the major range and each of the two minor ranges. The anisotropy code was taken from GSLIB. Note that in http://www.gslib.com/sec_gb.html it is reported that this code has a bug. Quoting from this site: “The third angle in all GSLIB programs operates in the opposite direction than specified in the GSLIB book. Explanation - The books says (pp27) the angle is measured clockwise when looking toward the origin (from the postive principal direction), but it should be counter-clockwise. This is a documentation error. Although rarely used, the correct specification of the third angle is critical if used.”

(Note that \texttt{anis = c(p, s)} is equivalent to \texttt{anis = c(p, 0, 0, s, 1).})

The implementation in gstat for 2D and 3D anisotropy was taken from the gslib (probably 1992) code. I have seen a paper where it is argued that the 3D anisotropy code implemented in gslib (and so in gstat) is in error, but I have not corrected anything afterwards.

Author(s)

Edzer Pebesma

References

http://www.gstat.org/


For the validity of variogram models on the sphere, see Huang, Chunfeng, Haimeng Zhang, and Scott M. Robeson. On the validity of commonly used covariance and variogram functions on the sphere. Mathematical Geosciences 43.6 (2011): 721-733.

See Also

\texttt{show.vgms} to view the available models, \texttt{fit.variogram}, \texttt{variogramLine}, \texttt{variogram} for the sample variogram.

Examples

\begin{verbatim}
vgm()
vgm("Sph")
vgm(NA, "Sph", NA, NA)
vgm(, "Sph") # "Sph" is second argument: NO nugget in this case
vgm(10, "Exp", 300)
x <- vgm(10, "Exp", 300)
vgm(10, "Nug", 0)
vgm(10, "Exp", 300, 4.5)
vgm(10, "Mat", 300, 4.5, kappa = 0.7)
vgm(5, "Exp", 300, add.to = vgm(5, "Exp", 60, nugget = 2.5))
vgm(10, "Exp", 300, anis = c(30, 0.5))
vgm(10, "Exp", 300, anis = c(30, 10, 0.5, 0.3))
\end{verbatim}
# Matern variogram model:

```
vgm(1, "Mat", 1, kappa=3)
```

```
x <- vgm(0.39527463, "Sph", 953.8942, nugget = 0.06105141)
x
```

```
print(x, digits = 3);
```

```
# to see all components, do
print.data.frame(x)
```

```
vv=vgm(model = "Tab", covtable =
variogramLine(vgm(1, "Sph", 1), 1, n=1e4, min = 0, covariance = TRUE))
vgm(c("Mat", "Sph"))
vgm( c("Mat", "Sph")) # no nugget
```

---

**vgm.panel.xyplot**

*panel functions for most of the variogram plots through lattice*

### Description

Variogram plots contain symbols and lines; more control over them can be gained by writing your own panel functions, or extending the ones described here; see examples.

### Usage

```
vgm.panel.xyplot(x, y, subscripts, type = "p", pch = plot.symbol$pch,
col, col.line = plot.line$col, col.symbol = plot.symbol$col,
lty = plot.line$lty, cex = plot.symbol$cex, ids, lwd = plot.line$lwd,
model = model, direction = direction, labels, shift = shift, mode = mode, ...)
```

### Arguments

- **x**: x coordinates of points in this panel
- **y**: y coordinates of points in this panel
- **subscripts**: subscripts of points in this panel
- **type**: plot type: "l" for connected lines
- **pch**: plotting symbol
- **col**: symbol and line color (if set)
- **col.line**: line color
- **col.symbol**: symbol color
- **lty**: line type for variogram model
- **cex**: symbol size
- **ids**: gstat model ids
- **lwd**: line width
model | variogram model
direction | direction vector \( \text{c(dir.horizontal, dir.ver)} \)
labels | labels to plot next to points
shift | amount to shift the label right of the symbol
mode | to be set by calling function only
line.pch | symbol type to be used for point of selected point pairs, e.g. to highlight point pairs with distance close to zero
pairs | two-column matrix with pair indexes to be highlighted
... | parameters that get passed to \text{lpoints}

\textbf{Value}

ignored; the enclosing function returns a plot of class \text{trellis}

\textbf{Author(s)}

Edzer Pebesma

\textbf{References}

\url{http://www.gstat.org/}

\textbf{See Also}

\text{plot.gstatVariogram, vgm}

\textbf{Examples}

library(sp)
data(meuse)
coordinates(meuse) <- c("x", "y")
library(lattice)
mypanel = function(x,y,\ldots) {
  vgm.panel.xyplot(x,y,\ldots)
  panel.abline(h=var(log(meuse$zinc)), color = 'red')
}
plot(variogram(log(zinc)-1,meuse), panel = mypanel)
vgmArea

point-point, point-area or area-area semivariance

Description

Compute point-point, point-area or area-area variogram values from point model

Usage

vgmArea(x, y = x, vgm, ndiscr = 16, verbose = FALSE, covariance = TRUE)

Arguments

x object of class SpatialPoints or SpatialPolygons
y object of class SpatialPoints or SpatialPolygons
vgm variogram model, see vgm
ndiscr number of points to discretize an area, using spsample
verbose give progress bar
covariance logical; compute covariances, rather than semivariances?

Value

semivariance or covariance matrix of dimension length(x) x length(y)

Author(s)

Edzer Pebesma

Examples

library(sp)
demo(meuse, ask = FALSE, echo = FALSE)
vgmArea(meuse[1:5,], vgm = vgm(1, "Exp", 1000)) # point-point
vgmArea(meuse[1:5,], meuse.area, vgm = vgm(1, "Exp", 1000)) # point-area
vgmAreaST

Function that returns the covariances for areas

Description

Function that returns the covariances for areas based on spatio-temporal point variograms for use in the spatio-temporal area-to-point kriging

Usage

vgmAreaST(x, y = x, model, ndiscrSpace = 16, verbose = FALSE, covariance = TRUE)

Arguments

x  spatio-temporal data frame
y  spatio-temporal data frame
model  spatio-temporal variogram model for point support
ndiscrSpace  number of discretisation in space
verbose  Boolean: default to FALSE, set to TRUE for debugging
covariance  Boolean: whether the covariance shall be evaluated, currently disfunction and set to TRUE

Value

The covariance between 'x' and 'y'.

Author(s)

Benedikt Graeler

See Also

vgmArea

Examples

# see demo('a2pinST')
vgmST

Constructing a spatio-temporal variogram

Description

Constructs a spatio-temporal variogram of a given type checking for a minimal set of parameters.

Usage

vgmST(stModel, ..., space, time, joint, sill, k, nugget, stAni, temporalUnit)

Arguments

- **stModel**: A string identifying the spatio-temporal variogram model (see details below). Only the string before an optional "_" is used to identify the model. This mechanism can be used to identify different fits of the same model (separable_A and separable_B will be interpreted as separable models, but carry different names).
- **...**: unused, but ensure an exact match of the following parameters.
- **space**: A spatial variogram.
- **time**: A temporal variogram.
- **joint**: A joint spatio-temporal variogram.
- **sill**: A joint spatio-temporal sill.
- **k**: The weighting of the product in the product-sum model.
- **nugget**: A joint spatio-temporal nugget.
- **stAni**: A spatio-temporal anisotropy; the number of space units equivalent to one time unit.
- **temporalUnit**: length one character vector, indicating the temporal unit (like secs)

Details

The different implemented spatio-temporal variogram models have the following required parameters (see as well the example section)

- **separable**: A variogram for space and time each and a joint spatio-temporal sill (variograms may have a separate nugget effect, but their joint sill will be 1) generating the call
  
  vgmST("separable", space, time, sill)

- **productSum**: A variogram for space and time each, and the weighting of product k generating the call
  
  vgmST("productSum", space, time, k)

- **sumMetric**: A variogram (potentially including a nugget effect) for space, time and joint each and a spatio-temporal anisotropy ratio stAni generating the call
vgmST("sumMetric", space, time, joint, stAni)

**simpleSumMetric**: A variogram (without nugget effect) for space, time and joint each, a joint spatio-temporal nugget effect and a spatio-temporal anisotropy ratio stAni generating the call

vgmST("simpleSumMetric", space, time, joint, nugget, stAni)

**metric**: A spatio-temporal joint variogram (potentially including a nugget effect) and stAni generating the call

vgmST("metric", joint, stAni)

**Value**

Returns an S3 object of class StVariogramModel.

**Author(s)**

Benedikt Graeler

**See Also**

fit.StVariogram for fitting, variogramSurface to plot the variogram and extractParNames to better understand the parameter structure of spatio-temporal variogram models.

**Examples**

# separable model: spatial and temporal sill will be ignored
# and kept constant at 1-nugget respectively. A joint sill is used.
separableModel <- vgmST("separable",
    space=vgm(0.9,"Exp", 147, 0.1),
    time =vgm(0.9,"Exp", 3.5, 0.1),
    sill=40)

# product sum model: spatial and temporal nugget will be ignored and kept
# constant at 0. Only a joint nugget is used.
prodSumModel <- vgmST("productSum",
    space=vgm(39, "Sph", 343, 0),
    time= vgm(36, "Exp", 3, 0),
    k=15)

# sum metric model: spatial, temporal and joint nugget will be estimated
sumMetricModel <- vgmST("sumMetric",
    space=vgm( 6.9, "Lin", 200, 3.0),
    time =vgm(10.3, "Lin", 15, 3.6),
    joint=vgm(37.2, "Exp", 84,11.7),
    stAni=77.7)

# simplified sumMetric model, only a overall nugget is fitted. The spatial,
# temporal and joint nuggets are set to 0.
simpleSumMetricModel <- vgmST("simpleSumMetric",
    space=vgm(20,"Lin", 150, 0),
    time =vgm(20,"Lin", 10, 0),
joint = vgm(20, "Exp", 150, 0), nugget = 1, stAni = 15)

# metric model
metricModel <- vgmST("metric",
joint = vgm(60, "Exp", 150, 10),
stAni = 60)

Precomputed variogram for PM10 in data set air

Description
Precomputed variogram for PM10 in data set air

Usage
data(vv)

Format
data set structure is explained in variogramST.

Examples
## Not run:
# obtained by:
library(spacetime)
library(gstat)
data(air)
suppressWarnings(proj4string(stations) <- CRS(proj4string(stations)))
rural = STFDF(stations, dates, data.frame(PM10 = as.vector(air)))
rr = rural[,"2005::2010"]
unsel = which(apply(as(rr, "xts"), 2, function(x) all(is.na(x))))
r5to10 = rr[-unsel,]
vv = variogram(PM10~1, r5to10, width=20, cutoff = 200, tlags=0:5)

## End(Not run)
**walker**  

---  

**Walker Lake sample and exhaustive data sets**

**Description**

This is the Walker Lake data sets (sample and exhaustive data set), used in Isaaks and Srivastava’s *Applied Geostatistics*.

**Usage**

```r
data(walker)
```

**Format**

This data frame contains the following columns:

- **Id** Identification Number
- **X** Xlocation in meter
- **Y** Ylocation in meter
- **V** V variable, concentration in ppm
- **U** U variable, concentration in ppm
- **T** T variable, indicator variable

**Note**

This data sets was obtained from the data sets on ai-geostats, [https://wiki.52north.org/bin/view/AI_GEOSTATS/WebHome](https://wiki.52north.org/bin/view/AI_GEOSTATS/WebHome)

**References**

*Applied Geostatistics* by Edward H. Isaaks, R. Mohan Srivastava; Oxford University Press.

**Examples**

```r
library(sp)
data(walker)
summary(walker)
summary(walker.exh)
```
Description

Daily average wind speeds for 1961-1978 at 12 synoptic meteorological stations in the Republic of Ireland (Haslett and raftery 1989). Wind speeds are in knots (1 knot = 0.5418 m/s), at each of the stations in the order given in Fig.4 of Haslett and Raftery (1989, see below)

Usage

data(wind)

Format

data.frame wind contains the following columns:

- **year**: year, minus 1900
- **month**: month (number) of the year
- **day**: day
- **RPT**: average wind speed in knots at station RPT
- **VAL**: average wind speed in knots at station VAL
- **ROS**: average wind speed in knots at station ROS
- **KIL**: average wind speed in knots at station KIL
- **SHA**: average wind speed in knots at station SHA
- **BIR**: average wind speed in knots at station BIR
- **DUB**: average wind speed in knots at station DUB
- **CLA**: average wind speed in knots at station CLA
- **MUL**: average wind speed in knots at station MUL
- **CLO**: average wind speed in knots at station CLO
- **BEL**: average wind speed in knots at station BEL
- **MAL**: average wind speed in knots at station MAL

data.frame wind.loc contains the following columns:

- **Station**: Station name
- **Code**: Station code
- **Latitude**: Latitude, in DMS, see examples below
- **Longitude**: Longitude, in DMS, see examples below
- **MeanWind**: mean wind for each station, metres per second
Note
This data set comes with the following message: “Be aware that the dataset is 532494 bytes long (that's over half a Megabyte). Please be sure you want the data before you request it.”

The data were obtained on Oct 12, 2008, from: http://www.stat.washington.edu/raftery/software.html

The data are also available from statlib.

Locations of 11 of the stations (ROS, Rosslare has been thrown out because it fits poorly the spatial correlations of the other stations) were obtained from: http://www.stat.washington.edu/research/reports/2005/tr475.pdf

Roslare lat/lon was obtained from google maps, location Roslare. The mean wind value for Roslare comes from Fig. 1 in the original paper.

Haslett and Raftery proposed to use a sqrt-transform to stabilize the variance.

Author(s)
Adrian Raftery; imported to R by Edzer Pebesma

References
These data were analyzed in detail in the following article:


and in many later papers on space-time analysis, for example:


Examples

data(wind)
supply(wind)
wind.loc
library(sp) # char2dms
wind.loc$y = as.numeric(char2dms(as.character(wind.loc["Latitude"])))
wind.loc$x = as.numeric(char2dms(as.character(wind.loc["Longitude"])))
coordinates(wind.loc) = ~x+y

## Not run:
# fig 1:
library(maps)
library(mapdata)
map("worldHires", xlim=c(-11,-5.4), ylim=c(51,55.5))
points(wind.loc, pch=16)
text(coordinates(wind.loc), pos=1, label=wind.loc$Station)

## End(Not run)

wind$time = ISOdate(wind$year+1900, wind$month, wind$day)
# time series of e.g. Dublin data:
plot(DUB-time, wind, type='l', ylab="windspeed (knots)", main="Dublin")
# fig 2:
wind = wind[(wind$month == 2 & wind$day == 29),]
wind$jday = as.numeric(format(wind$time, 'j'))
windsqrt = sqrt(0.5148 * as.matrix(wind[4:15]))
Jday = 1:366
windsqrt = windsqrt - mean(windsqrt)
daymeans = sapply(split(windsqrt, wind$jday), mean)
plot(daymeans ~ Jday)
lines(lowess(daymeans ~ Jday, f = 0.1))

# subtract the trend:
meanwind = lowess(daymeans ~ Jday, f = 0.1)$y
velocity = apply(windsqrt, 2, function(x) { x - meanwind })

# match order of columns in wind to Code in wind.loc:
pts = coordinates(wind.loc[match(names(wind[4:15]), wind.loc$Code),])

dists = spDists(pts, longlat=TRUE)
corv = cor(velocity)

# fig 3, but not really yet...
dists.nr = dists[!ros,!ros]
corv.nr = corv[!ros,!ros]

# now really get fig 3:
ros = rownames(corv) == "ROS"
dists.nr = dists[!ros,!ros]
corv.nr = corv[!ros,!ros]

# add outlier:
points(corv[ros,!ros] ~ dists[ros,!ros], pch=16, cex=.5)

# add correlation model:
lines(xdiscr, .968 * exp(- .00134 * xdiscr))
Index

* datasets
  coalash, 3
  DE_RB_2005, 4
  fulmar, 15
  jura, 24
  meuse.all, 40
  meuse.alt, 42
  ncp.grid, 43
  oxford, 45
  pcb, 47
  sic2004, 59
  sic97, 61
  tull, 63
  walker, 83
  wind, 84
* dplot
  image, 22
  map.to.lev, 40
  plot.gstatVariogram, 48
  plot.pointPairs, 50
  plot.viagramCloud, 52
  show.vgms, 58
  spplot.vcov, 62
* models
  fit.lmc, 7
  fit.StVariogram, 8
  fit.variogram, 11
  fit.variogram.gls, 13
  fit.variogram.reml, 14
  get.contr, 16
  gstat, 17
  hscat, 21
  krig2, 26
  krig2.cv, 30
  krig2St, 34
  krigTg, 38
  osbfim, 44
  predict, 53
  progress, 57
  variogram, 65
  variogramLine, 69
  variogramST, 70
  variogramSurface, 72
  vgm, 73
  vgm.panel.xyplot, 76
  vgmArea, 78
  vgmST, 80
* spatio-temporal
  variogramSurface, 72
  [.gstat (gstat), 17
  Chlorid92 (tull), 63
  coalash, 3
  DE_RB_2005, 4
  demstd (sic97), 61
  diff, 71
  estiStAni, 5
  extractPar, 6
  extractParNames, 9, 10, 81
  extractParNames (extractPar), 6
  fit.lmc, 7
  fit.StVariogram, 7, 8, 34, 72, 81
  fit.variogram, 8–10, 11, 13–15, 27, 31, 38, 48, 50, 68, 74, 75
  fit.variogram.gls, 13
  fit.variogram.reml, 11, 14
  fulmar, 15, 43
  get.contr, 16
  get_gstat_progress (progress), 57
  getGammas (variogramLine), 69

87
gstat, 7, 17, 26–29, 31, 32, 35, 36, 38, 39, 53, 55, 56
gstat.cv (krige.cv), 30
hscat, 21
identify, 53
idw (krige), 26
idw, formula, formula-method (krige), 26
idw, formula, sf-method (krige), 26
idw, formula, Spatial-method (krige), 26
idw, formula, ST-method (krige), 26
idw-methods (krige), 26
idw.locations (krige), 26
idw.spatial (krige), 26
idw@ (krige), 26
image, 22
image.data.frame, 23, 40
image.default, 23
jura, 24
juragrid.dat (jura), 24
krige, 20, 26, 32, 39, 40, 45, 53, 55, 56
krige, formula, formula-method (krige), 26
krige, formula, NULL-method (krige), 26
krige, formula, sf-method (krige), 26
krige, formula, Spatial-method (krige), 26
krige, formula, ST-method (krige), 34
krige-methods (krige), 26
krige.cv, 30
krige.cv, formula, formula-method (krige.cv), 30
krige.cv, formula, sf-method (krige.cv), 30
krige.cv, Spatial-method (krige.cv), 30
krige.cv, locations (krige.cv), 30
krige.cv, spatial (krige.cv), 30
krige.locations (krige), 26
krige.spatial (krige), 26
krige@, 35, 36
krige@ (krige), 26
krigeSimCE, 33, 37
krigeST, 10, 34
krigeSTSimTB, 34, 36
krigeSTg (krigeST), 34
krigeTg, 36, 38
locator, 53

lpoints, 77
map.to.lev, 40
meuse.all, 40, 42
meuse.alt, 41, 42
ncp.grid, 16, 43, 47
optim, 9
ossfim, 44
oxford, 45
panel.pointPairs (vgm.panel.xyplot), 76
pcb, 47
plot.gstatVariogram, 48, 52, 53, 68, 70, 77
plot.pointPairs, 50, 53
plot.StVariogram, 72
plot.StVariogram (plot.gstatVariogram), 48
plot.variogramCloud, 51, 52, 68
plot.variogramMap (plot.gstatVariogram), 48
plot.variogramModel (vgm), 73
predict, 16, 17, 20, 26, 28, 29, 31, 32, 36, 38–40, 53, 55
prediction.dat (jura), 24
print.gstat (jura), 17
print.gstatVariogram, 68
print.gstatVariogram (variogram), 65
print.variogramCloud (variogram), 65
print.variogramModel (vgm), 73
progress, 57
set.gstat_progress (progress), 57
show.vgms, 58, 75
sic.grid (sic2004), 59
sic.pred (sic2004), 59
sic.test (sic2004), 59
sic.train (sic2004), 59
sic.val (sic2004), 59
sic2004, 59
sic97, 61
sic_full (sic97), 61
sic_obs (sic97), 61
SpatialPoints, 78
SpatialPolygons, 54, 78
SpatialPolygonsDataFrame, 54
spplot.vcov, 62
spsample, 54, 78
ST, 35
STDF, 70
STIDF, 70, 71
STSDF, 70

transect.dat (jura), 24

tull, 63
tull36 (tull), 63
TULLNREG (tull), 63

validation.dat (jura), 24
variogram, 7, 8, 11, 12, 22, 48, 50, 53, 65, 70, 75
variogram.default, 66
variogramLine, 50, 59, 69, 72, 75
variogramST, 9, 65, 67, 68, 70, 82
variogramSurface, 34, 72, 81
vgm, 5, 7, 8, 11, 12, 18, 27, 31, 38, 48, 50, 59, 68, 73, 77, 78
vgm.panel.xyplot, 76
vgmArea, 78, 79
vgmAreaST, 34, 79
vgmST, 6, 7, 9, 34, 37, 72, 80
vv, 82

walker, 83
wind, 84

xyplot, 49
xyz2img, 23
xyz2img (image), 22