Package ‘geofd’

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**Description**

Kriging based methods are used for predicting functional data (curves) with spatial dependence. Initially the curves are pre-processed by fitting a Fourier or B-splines basis functions. Then the spatial dependence among curves is estimated by means of the trace-variogram function. Finally the parameters for performing prediction by Ordinary Kriging at unsampled locations are estimated by solving a linear system based on the estimated trace-variogram.

**Details**

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geofd-package Spatial prediction for function value data

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**Description**

Fits a parametric model to a empirical variogram and estimates covariance parameters. Additionally all fitted variogram models are plotted for verification purpose.

**Usage**

```r
fit.tracevariog(emp.trace.vari, models, sigma2.0, phi.0,
                fix.nugget=FALSE, nugget=0,
                fix.kappa=TRUE, kappa=0.5,
                max.dist.variogram=NULL)
```

**Arguments**

- `emp.trace.vari` empirical trace-variogram. An object returned from the `variog` function.
- `models` a character vector of correlation function names used in geoR against which empirical trace variogram will be fitted.
- `sigma2.0` initial value for the covariance parameter $\sigma^2$ (partial sill). For further details see documentation for the parameter `ini.cov.pars` from the `variofit` function.
phi.0 initial value for the covariance parameter $\phi$ (range). For further details see documentation for the parameter init.cov.pars from the variofit function.

fix.nugget logical, indicating whether the nugget parameter should be estimated or not. For further details see documentation for the parameter nugget from the variofit function.

nugget value for the nugget parameter. For further details see documentation for the parameter nugget from the variofit function.

fix.kappa logical, indicating whether the kappa parameter should be estimated or not. For further details see documentation for the parameter fix.kappa from the variofit function.

kappa value of the smoothness parameter. For further details see documentation for the parameter kappa from the variofit function.

max.dist.variogram a numerical value defining the maximum distance considered when fitting the variogram. For further details see documentation for the parameter max.dist from the variofit function.

Details

This function makes use of the variofit function.

Variogram models and parameters

When the cov.model parameter is NULL a function determines the optimal model between spherical, exponential gaussian and matern using the received parameters. The arguments sigma2.0 and phi.0 are used as initial values for fitting each variogram model.

The parameters fix.nugget, nugget, fix.kappa, kappa and max.dist.variogram are the same for each variogram model specified in models.

Value

A list with the following components:

trace.vari choosed theoretical variogram model
trace.vari.array vector of all fitted theoretical variogram models

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References


**l2.norm**

*Calculates L2 norm among functions*

**Description**

Calculates the integral of the squared differences between functions

**Usage**

```r
l2.norm(s, datafd, M)
```

**Arguments**

- `s`: number of sites where the original dataset was measured
- `datafd`: a functional data object representing a smoothed dataset. See DETAILS below.
- `M`: symmetric matrix defining the roughness penalty for functions expressed in terms of a B-spline or Fourier basis. See DETAILS below.

**Details**

**Roughness penalty matrix**

This matrix is the output of one of the following functions: `fourierpen` y `bsplinepen`. The used function depends upon the smoothing type which is going to be applied.

When the roughness penalty matrix is being calculated, the following considerations are taken into account:

- The differential operator passed as parameter for both `fourierpen` and `bsplinepen` is always zero.
- When the selected smooth method is bsplines, the basis object passed to `bsplinepen` is the output of the function `create.bspine.basis` using `argvals` as the rangeval parameter, `nbasis` as the number of basis functions parameter and the default order of b-splines, which is four, a cubic spline, as the `norder` parameter.
- When the selected smooth method is fourier, the basis object is the output of the function `fourierpen`. The parameters `rangeval` and `nbasis` are the same as for `create.bspine.basis`, and the `period` parameter as the number of observations on each curve.

**Value**

The calculated matrix of squared differences between each observation for each measured site. This matrix has two properties:

- Is symmetric.
- It’s diagonal is filled with zeros.
maritimes.avg

See Also

okfd for doing Ordinary Kriging for function-value data, trace.vario for functional empirical trace variogram calculation, fit.tracevariog for fitting a variogram model in the functional scenario.

maritimes.avg      Moncton averages

Description

Moncton averages

Usage

data(maritimes.avg)

Format

A matrix with 365 averages.

maritimes.coords      Coordinates of the sites referred by maritimes.data

Description

The geographical coordinates in decimal degrees of 35 weather stations.

Usage

data(maritimes.coords)

Format

A matrix with the coordinates of 35 weather stations.

Source

The coordinates were obtained from the database of geographic coordinate information http://www.tageo.com
maritimes.data  

Maritime provinces temperatures

Description

Temperature measurements recorded at 35 weather stations located in the Maritime Provinces over a region of Canada consisting of three provinces: Nova Scotia (NS), New Brunswick (NB), and Prince Edward Island (PEI).

Usage

data(maritimes.data)

Format

A matrix with 365 observations on 35 sites.

Details

This data set contains information of daily temperatures averaged over the years 1960 to 1994 (February 29th combined with February 28th)

Source

The data for each station were obtained from the Meteorological Service of Canada http://climate.weather.gc.ca

okfd  

Function for doing Ordinary Kriging for function-value Data

Description

This function allows to carry out prediction by Ordinary Kriging for function-value data by considering a Fourier or B-splines basis for smoothing the observed data set

Usage

okfd(new.coords, coords, data, smooth.type=NULL, nbasis=max(50, dim(data)[1]), 
argvals=seq(0, 1, len = dim(data)[1]), lambda=0, cov.model=NULL, 
fix.nugget=FALSE, nugget=0, fix.kappa=TRUE, 
kappa=0.5, max.dist.variogram=NULL)
Arguments

new.coords  an n x 2 matrix containing the coordinates of the new n sites where functional Kriging has to be done
coords  an s x 2 matrix containing the coordinates of the n sites where functional data are observed
data  an m x s matrix with values for the observed functions
smooth.type  a string with the name of smoothing method to be applied to data. Available choices are: "bsplines" and "fourier".
nbasis  a numeric value defining the number of basis functions used to smooth the discrete data set recorded at each site
argvals  a vector of argument values corresponding to the observations in matrix data
lambda  optional. Penalization parameter for smoothing the observed functions.
cov.model  a string with the name of the correlation function. Default is NULL, see DETAILS below. For further details see documentation for the parameter cov.model from the variofit function.
fix.nugget  logical, indicating whether the nugget parameter should be estimated or not. For further details see documentation for the parameter nugget from the variofit function.
nugget  value for the nugget parameter. For further details see documentation for the parameter nugget from the variofit function.
fix.kappa  logical, indicating whether the kappa parameter should be estimated or not. For further details see documentation for the parameter fix.kappa from the variofit function.
kappa  value of the smoothness parameter. For further details see documentation for the parameter kappa from the variofit function.
max.dist.variogram  a numerical value defining the maximum distance considered when fitting the variogram. For further details see documentation for the parameter max.dist from the variofit function.

Details

This function is a common sequence of the proposed process for doing Ordinary Kriging in the functional scenario, covers from the preparation of the original data and variogram estimation, unto data prediction.

Functional data object

This is an object of the class fd it can be created using some functions like Data2fd or smooth.basis, take in count if a penalization parameter is going to be used.

Penalization parameter

The penalization parameter lambda is used in both smoothing methods. When the selected smooth method is:

1. bsplines, the function which uses it is fdPar
2. Fourier, the function which uses it is `Data2fd`

**Functional data object**

The function which creates the functional data object is determined based on the selected smooth method:

- When it is bsplines, the functional data object must be created using two different functions, `fdPar` and `smooth.basis` in order to include the penalization parameter lambda.
- When it is fourier, the functional data object is directly returned by `Data2fd` because it includes the penalization parameter, the basis object, the argument values and the data, all at the same time.

**Value**

A list with the following components:

- `coords`: a matrix containing the coordinates of the sites where functional data are observed.
- `data`: a matrix with values for the observed functions.
- `argvals`: a vector of argument values corresponding to the observations in matrix data.
- `nbasis`: a numeric value defining the number of basis functions used to smooth the discrete data set recorded at each site.
- `lambda`: penalization parameter for smoothing the observed functions.
- `new.coords`: matrix containing the coordinates of the new sites where functional Kriging has to be done.
- `emp.trace.vari`: empirical trace-variogram.
- `trace.vari`: chosen theoretical variogram model.
- `krig.new.data`: predicted values for the new sites.
- `pred.var`: prediction variance.
- `trace.vari.array`: vector of all fitted variogram models.
- `datafd`: a functional data object containing a smooth of the data.

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**References**


See Also

l2.norm for calculating L2 norm among functions, trace.variog for functional empirical trace variogram calculation, fit.tracevariog for fitting a variogram model in the functional scenario.

Examples

# First example: one site prediction using B-splines for smoothing

data(maritimes.avg)
data(maritimes.coords)
data(maritimes.data)

coord.cero <- matrix(c(-64.06, 45.79), nrow=1, ncol=2)
n <- dim(maritimes.data)[1]

argvals <- seq(1, n, by=1)

# Prediction by okfd

okfd.res <- okfd(new.coords=coord.cero, coords=maritimes.coords,
data=maritimes.data, nbasis=65, argvals=argvals,
  fix.nugget=TRUE, kappa=0.7)

# Smoothed and predicted curves, and predicted site average values are plotted

plot(okfd.res$data, lty=1, col=8,
  main="Smoothed", xlab="Day", ylab="Temperature (Degrees C)"
)

lines(okfd.res$argvals, okfd.res$krig.new.data,
col=1, lwd=2, type="l", lty=1,
  main="Predictions", xlab="Day", ylab="Temperature (Degrees C)"
)

lines(maritimes.avg, type="p", pch=20, cex=0.5, col=2, lwd=1)

# Second example: multiple sites prediction using Fourier basis functions for smoothing

data(maritimes)
n <- dim(maritimes.data)[1]

argvals <- seq(1, n, by=1)

col1 <- sample( (min(maritimes.coords[,1]) * 100):(max(maritimes.coords[,1]) * 100),
  10, replace=TRUE)/100

col2 <- sample( (min(maritimes.coords[,2]) * 100):(max(maritimes.coords[,2]) * 100),
  10, replace=TRUE)/100

new.coords <- cbind(col1, col2)
# Prediction by okfd

okfd.res<-okfd(new.coords=new.coords, coords=maritimes.coords, data=maritimes.data, smooth.type="fourier", nbasis=65, argvals=argvals)

# The smoothed and predicted curves are plotted

par(mfrow=c(1,2))

plot(okfd.res$data, lty=1, col=8, main="Smoothed", xlab="Day", ylab="Temperature (Degrees C)")

matplot(okfd.res$argvals, okfd.res$krig.new.data, col=1, lwd=1, type="l", lty=1, main="Predictions", xlab="Day", ylab="Temperature (Degrees C)")

okfd.cv

Function for doing Cross-Validation analysis for Ordinary Kriging for function-value data

### Description

Unreviewed

### Usage

okfd.cv(coords, data, argnames=c("argument", "sites", "values"), one.model=TRUE, smooth.type=NULL, array.nbasis=max(50,dim(data)[1]), argvals=seq(0,1,1en=dim(data)[1]), array.lambda=0, cov.model=NULL, fix.nugget=FALSE, nugget=0, fix.kappa=TRUE, kappa=0.5, max.dist.variogram=NULL)

### Arguments

- **coords**: coordinates of the sites where functional data are observed (dim: s by 2)
- **data**: matrix with values for the observed functions (dim: m by s)
- **argnames**: a character vector of length three containing: the name of the argument (argvals), a description of the sites (coord), the name of the observed function values.
- **one.model**: logical, indicates whether the cross validation is going to be done just one model or one model for each site. Default is TRUE. See details below.
- **smooth.type**: a string with the name of smoothing method to be applied to data. Available choices are: "bsplines" and "fourier".
- **array.nbasis**: array with values for the number of elements in the cubic B-spline basis.
- **argvals**: a set of argument values. (length: m)
array.lambda array of penalization parameters for smoothing the observed functions.
cov.model a string with the name of the correlation function. Default is NULL, see DETAILS below. For further details see documentation for the parameter cov.model from the `variofit` function.
fix.nugget logical, indicating whether the nugget parameter should be estimated or not. For further details see documentation for the parameter nugget from the `variofit` function.
nugget value for the nugget parameter. For further details see documentation for the parameter nugget from the `variofit` function.
fix.kappa logical, indicating whether the kappa parameter should be estimated or not. For further details see documentation for the parameter fix.kappa from the `variofit` function.
kappa value of the smoothness parameter. For further details see documentation for the parameter kappa from the `variofit` function.
max.dist.variogram a numerical value defining the maximum distance considered when fitting the variogram. For further details see documentation for the parameter max.dist from the `variofit` function.

Details

Validation models

The parameter one.model is used to define the models used in the cross validation:

- If it is TRUE, a model and smoothed data are created before the beginning and used inside the cross validation process.
- If it is FALSE, then for each site a model and smoothed data are created and used on each iteration.

Value

A list with the following components:

k.opt unreviewed
l.opt unreviewed
krig.cv unreviewed
mse.cv unreviewed
mse.cv.opt unreviewed
fd.models unreviewed

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References


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**plot.geofd**  
*Plot Trace Variogram and adjusted models*

**Description**

This function produces a plot of an object of class geofd which contains...

**Usage**

```r
## S3 method for class 'geofd'
plot(x, emp.trace.vari=x$emp.trace.vari,
     trace.vari.array=x$trace.vari.array,
     colors=rainbow(length(trace.vari.array)), ...)
```

**Arguments**

- `x`: a list containing elements `emp.trace.vari` and `trace.vari.array` described below. Typically an object of the class "geofd". If not provided the arguments `emp.trace.vari` and `trace.vari.array` must be provided instead.
- `emp.trace.vari`: empirical trace-variogram.
- `trace.vari.array`: vector of variogram models.
- `colors`: a character vector of color names used to plot each variogram model. Dimensions must be the same of `trace.vari.array`.
- `...`: graphical arguments to be passed to `plot`.

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**trace.variog**  
*Empirical Variograms for function-value data*

**Description**

Computes empirical trace-variograms using the L2 norm matrix for the semivariance values. Output a variogram cloud.

**Usage**

```r
trace.variog(coords, L2norm, bin=FALSE, max.dist, uvec="default",
             breaks="default", nugget.tolerance)
```
**Arguments**

- **coords**: an s x 2 matrix containing the coordinates of the n sites where functional data are observed.
- **L2norm**: L2 norm among functions.
- **bin**: logical, indicating whether the output is the binned variogram.
- **max.dist**: a numerical value defining the maximum distance for the variogram.
- **uvec**: a vector with values defining the centers of the bins or the number of bins as in `variog`. Only used when `bin = TRUE`.
- **breaks**: a vector with values defining the variogram binning as in `variog`. Only used when `bin = TRUE`.
- **nugget.tolerance**: a numeric value defining the shortest lag distance. Only used when `bin = TRUE`.

**Details**

**Binned variogram** This is just a visual feature adapted from the cloud variogram and it doesn’t have any relation against the fitting of the variogram model or the calculation of the predictions. The binning is made in the same manner as in `variog` because it uses the `.define.bins` function.

**Value**

An object of the class variogram as the the `variog` function which is a list with the following components:

- **u**: a vector with distances.
- **v**: a vector with estimated variogram values at distances given in u.
- **max.dist**: maximum distance of the variogram.
- **output.type**: variogram type.
- **Eu.d**: euclidian distance array among sites.
- **L2norm**: echoes the ‘L2norm’ argument.
- **bins.lim**: limits defining the interval spanned by each bin as in `variog`. Only returned when `bin = TRUE`.
- **nugget.tolerance**: echoes the ‘nugget.tolerance’ argument.

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References


Examples

```r
# First example: creating a binned variogram
# okfd first example

data(maritimes.avg)
data(maritimes.coords)
data(maritimes.data)
coord.cero <- matrix(c(-64.06, 45.79), nrow=1, ncol=2)
nc <- dim(maritimes.data)[1]
argvals <- seq(1, n, by=1)
okfd.res <- okfd(new.coords=coord.cero, coords=maritimes.coords,
data=maritimes.data, nbasis=65, argvals=argvals, fix.nugget=TRUE,
kappa=0.7)

# Calculating the empirical trace bin variogram
new.emp.trace.vari <- trace.variog(coords=okfd.res$coords,
  L2norm=okfd.res$emp.trace.vari$L2norm, bin=TRUE)

# The empirical trace cloud variogram is replaced with the trace bin variogram
okfd.res$emp.trace.vari <- new.emp.trace.vari

# The modified okfd result is plotted
plot(okfd.res)
```
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