Package ‘intamap’

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Description Geostatistical interpolation has traditionally been done by manually fitting a variogram and then interpolating. Here, we introduce classes and methods that can do this interpolation automatically. Pebesma et al (2010) gives an overview of the methods behind and possible usage <doi:10.1016/j.cageo.2010.03.019>.

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R topics documented:

intamap-package .................................................. 2
bayesCopula .................................................. 6
blockPredict .................................................. 8
checkSetup .................................................. 10
coarsenGrid ................................. 11
conformProjections .......................... 12
copulaEstimation ............................ 14
createIntamapObject ......................... 16
estimateAnisotropy ......................... 19
estimateParameters ......................... 22
estimateTimeModel ......................... 24
generateTimeModels ......................... 25
getIntamapParams ......................... 26
getInterpolationMethodNames .............. 28
intamap .................................. 29
intamapExampleObject ..................... 30
interpolate ............................... 31
methodParameters ......................... 34
plotIntamap ................................ 35
postProcess ................................ 37
predictTime ............................... 38
preProcess ................................ 39
rotateAnisotropicData ..................... 40
spatialPredict ............................ 41
summaryIntamap ......................... 43
timeModels ................................ 44
unbiasedKrige ............................. 45
yamamotoKrige .............................. 47

Index 49

intamap-package  A package providing methods for automatic interpolation: pre-
               processing, parameter estimation, spatial prediction and post process-
               ing

Description

This package provides functionality for automatic interpolation of spatial data. The package was
originally developed as the computational back-end of the intamap web service, but is now a stand-
alone package as maintenance of the web service has ended.

General setup

The normal work flow for working with the intamap package can best be illustrated with the fol-
lowing R-script. The procedure starts with reading data and meta data, then setting up an object
which is used in the following functions: pre-process data, estimate parameters, compute spatial
predictions, and post process them (i.e., write them out):
library(intamap)

# set up intamap object, either manually:
obj <- list(
  observations = readOGR("PG:dbname=postgis", "eurdep.data"),
  predictionLocations = readOGR("PG:dbname=postgis", "eurdep1km.grid"),
  targetCRS = "+init=epsg:3035",
  params = getIntamapParams()
)
class(obj) = c("idw")

# or using createIntamapObject
obj = createIntamapObject(
  observations = readOGR("PG:dbname=postgis", "eurdep.data"),
  predictionLocations = readOGR("PG:dbname=postgis", "eurdep1km.grid"),
  targetCRS = "+init=epsg:3035", class = c("idw")
)

# run test:
checkSetup(obj)

# do interpolation steps:
ob = preProcess(obj)
ob = estimateParameters(obj) # faster
obj = spatialPredict(obj)
ob = postProcess(obj)

Our idea is that a script following this setup will allow the full statistical analysis required for the R back-end to the automatic interpolation service, and provides the means to extend the current (oversimplistic) code with the full-grown statistical analysis routines developed by INTAMAP partners. Running the package independently under R gives the user more flexibility in the utilization than what is possible through the web-interface.

Let us look into detail what the code parts do:

library(intamap)

The command library(intamap) loads the R code of the intamap package to the current R session, along with the packages required for this (sp, gstat, akima, automap, mvtnorm, evd, MASS). It is also recommended to install and load rgdal on those platforms where this package is available. All packages need to be available to the R session, which is possible after downloading them from the Comprehensive R Network Archives (CRAN) (https://cran.r-project.org)

# set up intamap object:
ob = createIntamapObject(
  observations = readOGR("PG:dbname=postgis", "eurdep.data"),
predictionLocations = readOGR("PG:dbname=postgis", "inspire1km.grid"),
targetCRS = "+init=epsg:3051",
class = "idw"
)

This code sets up a list object called obj, and assigns a class (or a group of classes) to it. This list should hold anything we need in the next steps, and the bare minimum seems to be measured point data (which will be extended to polygon data) and prediction locations, and a suggestion what to do with it. Here, the data are read from a PostGIS database running on localhost; database connections over a network are equally simple to set up. From the database postgis the tables eurdep.data and inspire1km.grid are read; it is assumed that these have their SRID (spatial reference identifier) set.

The suggestion what to do with these data is put in the classes, idw. This will determine which versions of preProcess, parameterEstimate etc will be used: intamap provides methods for each of the generic functions preProcess, estimateParameters, spatialPredict, postProcess. Although it would be possible to apply two classes in this case (dataType in addition to idw), as the choice of pre- and post-processing steps tend to be data-dependent, we have tried to limit the number of classes to one for most applications.

The S3 method mechanism (used here) hence requires these versions to be called preProcess.idw, estimateParameters.idw, spatialPredict.idw, and postProcess.idw (and eventually also preProcess.eurdep and preProcess.eurdep).

To see that, we get in an interactive session:

> library(intamap)
> Loading required package: sp
> Loading required package: gstat
> Loading required package: rgdal
> Geospatial Data Abstraction Library extensions to R successfully loaded
> methods(estimateParameters)
> [1] estimateParameters.automap* estimateParameters.copula*
> [3] estimateParameters.default* estimateParameters.idw*
> [5] estimateParameters.linearVariogram* estimateParameters.transGaussian*
> [7] estimateParameters.yamamoto*

Now if a partner provides additional methods for BayesianKriging, one could integrate them by

class(obj) = "BayesianKriging"

and provide some or all of the functions preProcess.BayesianKriging, estimateParameters.BayesianKriging, spatialPredict.BayesianKriging, and postProcess.BayesianKriging, which would be called automatically when using their generic form (preProcess etc).

It is also possible to provide a method that calls another method. Further, for each generic there is a default method. For estimateParameter and spatialPredict these print an error message and stop, for the pre- and postprocessing the default methods may be the only thing needed for the full procedure; if no preProcess.BayesianKriging is found, preProcess.default will be used when the generic (preProcess) is called.

If a method does something, then it adds its result to the object it received, and returns this object. If it doesn’t do anything, then it just passes (returns) the object it received.
To make these different methods exchangable, it is needed that they can all make the same assumptions about the contents of the object that they receive when called, and that what they return complies with what the consequent procedures expect. The details about that are given in the descriptions of the respective methods, below.

Because a specific interpolation method implemented may have its peculiar characteristics, it may have to extend these prescriptions by passing more information than described below, for example information about priors from estimateParameters to spatialPredict.

The choice between methods is usually done based on the type of problem (extreme values present, computation time available etc.). The possibility for parallel processing of the prediction step is enabled for some of the main methods. To be able to take advantage of multiple CPUs on a computer, the package doParallel must be installed, additionally the parameter nclus must be set to a value larger than 1.

**Input object components**

- **observations** object of class \code{SpatialPointsDataFrame}, containing a field \code{value} that is the target variable.
- **predictionLocations** object extending class \code{Spatial}, containing prediction locations.
- **targetCRS** character; target CRS or missing
- **formulaString** formula string for parameter estimation and prediction functions
- **params** list of parameters, to be set in \code{getIntamapParams}. These parameters include:
  - **doAnisotropy = FALSE** Defining whether anisotropy should be calculated
  - **removeBias = NA** Defining whether biases should be removed, and in case yes, which ones (localBias and regionalBias implemented)
  - **addBias = NA** Defining which biases to be added in the \code{postProcess} function. This has not yet been implemented.
  - **biasRemovalMethod = "LM"** character; specifies which methods to use to remove bias. See below.
  - **doSegmentation = FALSE** Defining if the predictions should be subject to segmentation. Segmentation has been implemented, but not the use of it.
  - **nmax = 50** 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, 50 observations are used.
  - **ngrid = 100** The number of grid points to be used if an Averaged Cumulative Distribution Function (ACDF) needs to be computed for unbiased kriging
  - **nsim=100** Number of simulations when needed
  - **block = numeric(0)** 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 \code{predict.gstat}. By default, predictions or simulations refer to the support of the data values.
  - **processType = “gaussian”** If known - the distribution of the data. Defaults to gaussian, analytical solutions also exists in some cases for logNormal. This setting only affects a limited number of methods, e.g. the block predicton
**confProj = FALSE**  If set, the program will attempt conform projections in `preProcess`, calling the function `conformProjections`.

**nclus = 1**  The number of clusters to use, if applying to a method which can run processes in parallel. Currently implemented for methods `automap`, `copula` and `psgp`.

**debug.level = 0**  Used in some functions for giving additional output. See individual functions for more information.

... Additional parameters that do not exist in the default parameter set, particularly parameters necessary for new methods within the `intamap` package

### References


---

**bayesCopula**  
*Performs spatial interpolation using copulas*

**Description**

Calculates predictive mean, predictive variance, predictive quantiles and exceedance probabilities for certain thresholds in the spatial copula model.

**Usage**

```r
bayesCopula(obj, estimates, search=10, calc=list(mean=TRUE, variance=TRUE), testMean=FALSE)
```

**Arguments**

- **obj**  
  Intamap object including observations and predictionLocations, see `intamap-package`

- **estimates**  
  List of estimated parameters (typically obtained by calling `copulaEstimation`)

- **search**  
  local prediction: number of observed locations considered for prediction at each unknown point

- **calc**  
  list of what prediction type is required:
  - `mean = TRUE` if the predictive mean should be calculated, FALSE otherwise
  - `variance = TRUE` if the predictive variance should be calculated, FALSE otherwise
  - `quantiles` = NULL Vector of desired predictive quantiles, e.g. 0.95 or 0.05
  - `excprob` = NULL Vector of thresholds, where the probability of exceeding this threshold is desired

- **testMean**  
  Whether or not the predictive means (if calculated) should be tested for being reasonable.
bayesCopula

Details

bayesCopula is used for plug-in prediction at unobserved spatial locations. The name of the function is somewhat misleading since no Bayesian approach is implemented so far. It is possible to calculate numerically the predictive mean and variance for both the Gaussian and the chi-square spatial copula model. Exceedance probabilities and predictive quantiles are only supported for the Gaussian copula model. Note that it may occur that the predictive distribution has no finite moments. In this case, a possible predictor is the median of the predictive distribution. If testMean=TRUE and the predictive means have no reasonable values, the median is automatically calculated and a warning is produced.

The copula prediction method is computationally demanding. There is a possibility of running it as a parallel process by setting the parameter nclus > 1 for the interpolation process. This requires a previous installation of the package doParallel.

Value

List with the following elements:

- mean: Mean of the predictive distribution. NULL if not calculated.
- variance: Variance of the predictive distribution. NULL if not calculated.
- quantiles: Quantiles of the predictive distribution NULL if not calculated.
- excprob: Probabilities for the predictive distribution to exceed predefined thresholds. NULL if not calculated.

Author(s)

Hannes Kazianka

References


See Also
copulaEstimation, spatialPredict, estimateParameters

Examples

```r
## Not run:
data(intamapExampleObject)
## estimate parameters for the copula model
copula <- list(method="norm")
anisotropy <- list(lower = c(0,1), upper = c(pi, Inf), params = c(pi/3, 2))
correlation <- list(model = "Ste", lower=c(0.01, 0.01, 0.01), upper = c(0.99, Inf, 20),
```
params = c(0.05, 4, 3))
margin <- list(name = "gev", lower = c(0.01, -Inf), upper = c(Inf, Inf), params = c(30, 0.5))
trend <- list(F = as.matrix(rep(1, 196)), lower = -Inf, upper = Inf, params = 40)
estimates <- copulaEstimation(intamapExampleObject, margin, trend, correlation, anisotropy, copula)
## make predictions at unobserved locations
predictions<-bayesCopula(intamapExampleObject, estimates, search = 25,
calc = list(mean = TRUE, variance = TRUE, excprob = 40, quantile = 0.95))
## End(Not run)

### Description

blockPredict is a generic method for prediction of spatially aggregated variables within the intamap-package package.

### Usage

blockPredict(object, ...)

### Arguments

- **object**: a list object of the type described in intamap-package
- **...**: other arguments that will be passed to the requested interpolation method. See the individual interpolation methods for more information. The following arguments from object can be overrun through ...:
  - **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.gstat. By default, predictions or simulations refer to the support of the data values.
  - **cellsize**: size of cells for discretization of blocks for numerical simulation

### Details

The function blockPredict is a wrapper around the spatialPredict.block function within the intamap-package package, to simplify the calls for block predictions.

Block predictions are spatial predictions assumed to be valid for a certain area. The blocks can either be given by passing SpatialPolygons as the predictionLocations or by passing the block-argument through the parameters of the object or through the ...-argument.

There are essentially two ways to solve the problems of block predictions.

- **analytical** block predictions can be found directly by block kriging
• numerical block predictions can be found through numerical simulations over a set of points within the block, the requested output is found by averaging over these simulations.

The analytical solutions are used when applicable. This is typically for ordinary kriging based methods and prediction types that can be found by linear aggregation (e.g., block mean).

If the prediction type necessitates simulations, this is done by subsampling the blocks. This can either be done block-wise, with a certain number of points within each block, with a certain cell size, or with a certain number of points.

automap Uses function **autoKrige** in the automap package. If object already includes a variogram model, **krige** in the gstat-package will be called directly.

**Value**

a list object similar to object, but extended with predictions at a the set of locations defined object.

**Author(s)**

Jon Olav Skoien

**References**


**See Also**

**gstat**, **autoKrige**

**Examples**

```r
# This example skips some steps that might be necessary for more complicated
tasks, such as estimateParameters and pre- and postProcessing of the data
data(meuse)
coordinates(meuse) = ~x+y
meuse$value = log(meuse$zinc)
data(meuse.grid)
griddded(meuse.grid) = ~x+y
proj4string(meuse) = CRS("+init=epsg:28992")
proj4string(meuse.grid) = CRS("+init=epsg:28992")

# set up intamap object:
obj = createIntamapObject(
  observations = meuse,
predictionLocations = meuse.grid[sample(1:length(meuse.grid),10),],
  # Prediction for a different projection possible if rgdal is available
targetCRS = ifelse(require(rgdal), "+init=epsg:3035", "+init=epsg:28992"),
class = "automap"
)

# do interpolation step:
```
checkSetup

Description
checkSetup will do some sanity checks on input data provided through object.

Usage
checkSetup(object, quiet = FALSE)

Arguments
object object, to be passed to preProcess, see intamap-package
quiet logical; TRUE to suppress OK statement

Details
checkSetup is a function that makes certain tests on the intamap object to make sure that it is suited for interpolation. Particularly, it will issue a warning or an error if one of the following conditions are met:

- observations is not an element of object
- observations contain less than 20 observations
- Some of the observation locations are duplicated
- formulaString is not an element of object
- None of the columns of observations has a name that corresponds to the independent variable of formulaString
- predictionLocations is not an element of object
- predictionLocations is not a Spatial object
• targetCRS is given, but observations and predictionLocations do not have CRS set
• addBias includes biases that are not part of removeBias

The function will issue a warning if it appears that predictionLocations and observations share a small region. This warning is given as it is a likely cause of errors, although it can also happen if predictionLocations are limited to one small cluster.

Value
returns TRUE if check passes, will halt with error when some some error condition is met.

Author(s)
Edzer J. Pebesma

References

coarsenGrid

Coarsening of a spatial grid

Description
coarsenGrid is a function that resamples a SpatialGridDataFrame.

Usage
coarsenGrid(object, coarse = 2, offset = sample(c(0:(coarse - 1)), 2, replace = TRUE))

Arguments
object a SpatialGridDataFrame or gridded SpatialPixelsDataFrame
coarse an integer telling how much the grid should be coarsened
offset integer giving the relative offset of the first point, see details below for a closer description

Details
The function coarsenGrid is a function that samples from a SpatialGridDataFrame. The argument coarse indicates that every coarse row and column will be sampled, starting with the row and column represented in offset. offset = c(0,0) implies that the smallest x- and y-coordinates will be a part of the resampled data set, offset = c(1,1) implies that sampling will start on the second row and column.
conformProjections

Value
a SpatialGridDataFrame.

Author(s)
Jon Olav Skoien

References

Examples
data(meuse.grid)
grided(meuse.grid) = ~x+y
newMeuseGrid = coarsenGrid(meuse.grid,coarse=2,offset=c(1,1))

conformProjections

Description
Getting a conformed projection for a set of Spatial* elements necessary for interpolation in the intamap-package.

Usage
conformProjections(object)

Arguments
object an object of the type described in intamap-package

Details
conformProjections is a function that attempts to reproject all projected elements in object to one common projection. The function is usually called with an intamap object as argument from createIntamapObject if the parameter confProj = TRUE. Thus it is a function that is usually not necessary to call separately.

The need for this function is because several of the functions in a typical spatial interpolation work flow inside the intamap-package require that the elements have a common projection. In addition, there are some functions which are not able to deal with unprojected spatial objects, i.e. objects with coordinates given in latitude and longitude. conformProjections will hence also attempt to reproject all elements that have coordinates in latitude and longitude, even in the cases where they all have the same projections.
conformProjections

If only one of observations or predictionLocations has a projection (or is longlat), the other one is assumed to be equal. A warning is issued in this case.

The common projection depends on the object that is passed to conformProjections. First of all, if intCRS (see below) is present as an element of the object, all elements will be reprojected to this projection. If not, intCRS will be set equal to the first projection possible in the list below.

**intCRS** Can be given as a component in object - and is the user-defined common projection used for interpolation

**targetCRS** Can be given as a component in object - and is the user-defined target projections

**predCRS** The projection of the predictionLocations in object

**obsCRS** The projection of the observations

**Value**

A list of the parameters to be included in the object described in intamap-package

**Author(s)**

Jon Olav Skoien

**References**


**Examples**

```r
data(meuse)
coordinates(meuse) = ~x+y
proj4string(meuse) <- CRS("+proj=stere +lat_0=52.15616055555555
+lon_0=5.38763888888889 +k=0.999908 +x_0=155000 +y_0=463000 +ellps=bessel +units=m")
predictionLocations = spsample(meuse, 50, "regular")

krigingObject = createIntamapObject(
observations = meuse,
predictionLocations = predictionLocations,
formulaString = as.formula("log(zinc)~1"),
intCRS = "+init=epsg:3035"
)

krigingObject = conformProjections(krigingObject)
proj4string(meuse)
proj4string(krigingObject$observations)
```
copulaEstimation  
**ML-estimation of the spatial copula model parameters**

**Description**
Estimates parameters of the spatial copula model using maximum likelihood.

**Usage**

copulaEstimation(obj, margin, trend, correlation, anisotropy, copula, tol=0.001,...)

**Arguments**

- **obj**
  - Intamap object, see description in intamap-package

- **margin**
  - list with the following elements:
    - **params**
      - Starting values for the parameters of the marginal distribution (excluding trend parameters)
    - **lower**
      - Lower bounds for the values of the parameters of the marginal distribution (excluding trend parameters)
    - **upper**
      - Upper bounds for the values of the parameters of the marginal distribution (excluding trend parameters)
    - **name**
      - Name of the family of marginal distributions. Possible names are: "norm", "lnorm", "gev", "t" and "logis"

- **trend**
  - list with the following elements:
    - **params**
      - Starting values for the parameters of the trend model (location parameter of the marginal distribution)
    - **lower**
      - Lower bounds for the values of the parameters of the trend model
    - **upper**
      - Upper bounds for the values of the parameters of the trend model
    - **F**
      - Design matrix.

- **correlation**
  - list with the following elements:
    - **model**
      - Correlation function model. Possible models are: "Ste", "Sph", "Gau" and "Exp"
    - **params**
      - Starting values for the parameters of the correlation function model
    - **lower**
      - Lower bounds for the values of the parameters of the correlation function model
    - **upper**
      - Upper bounds for the values of the parameters of the correlation function model

- **anisotropy**
  - list with the following elements:
    - **params**
      - Starting values for the parameters of geometric anisotropy. If **NULL**, then no anisotropy is considered.
    - **lower**
      - Lower bounds for the values of the parameters of geometric anisotropy. Usually c(0,1)
Copula estimation

Upper bounds for the values of the parameters of geometric anisotropy. Usually $c(\pi, \infty)$

Copula

- **method**: Either "norm" or "chisq", depending on which spatial copula model is used, the Gaussian or the chi-squared copula.
- **params**: Only used in case of the chi-squared copula: the squared non-centrality parameter of the non-central chi-squared distribution. Controls how far the chi-squared copula is from the Gaussian copula.
- **lower**: Only used in case of the chi-squared copula: the lower bound for the copula parameter. Usually set to $0$.
- **upper**: Only used in case of the chi-squared copula: the upper bound for the copula parameter. Usually set to $\infty$.
- **tol**: Tolerance level for the optimization process.

Details

CopulaEstimation performs maximum likelihood estimation of all possible parameters included in the Gaussian and chi-squared spatial copula model: parameters of the predefined family of marginal distributions (including spatial trend or external drift), correlation function parameters, parameters for geometric anisotropy and parameters for the copula (only used for the chi-squared copula model). Due to the large number of variables that need to be optimized, a profile-likelihood approach is used. Although convergence to a global optimum is not assured, the profile-likelihood method makes it less likely that the optimization routine, `optim`, gets stuck in a local optimum. The result of `copulaEstimation` is a list containing all parameter point estimates that are needed for plug-in spatial prediction. It is advisable to check the output of the algorithm by trying different starting values for the optimization.

Value

A list with the following elements:

- **margin**: Same as the input except that the list element "params" now consists of the optimized parameters of the marginal distribution function.
- **trend**: Same as the input except that the list element "params" now consists of the optimized parameters of the trend model.
- **correlation**: Same as the input except that the list element "params" now consists of the optimized parameters of the correlation function model.
- **anisotropy**: Same as the input except that the list element "params" now consists of the optimized parameters of geometric anisotropy.
- **copula**: Same as the input except that the list element "params" now consists of the optimized copula parameters.

Author(s)

Hannes Kazianka
References


See Also

`bayesCopula`, `spatialPredict`, `estimateParameters`

Examples

```r
data(intamapExampleObject)
## estimate parameters for the copula model

## Not run: copula<-list(method="norm")
anisotropy <- list(lower = c(0, 1), upper = c(pi, Inf), params = c(pi/3, 2))
correlation <- list(model = "Ste", lower = c(0.01, 0.01, 0.01), upper = c(0.99, Inf, 20),
               params = c(0.05, 4, 3))
margin <- list(name = "gev", lower = c(0.01, -Inf), upper = c(Inf, Inf), params = c(30, 0.5))
trend <- list(F = as.matrix(rep(1, 196)), lower = -Inf, upper = Inf, params = 40)
estimates <- copulaEstimation(intamapExampleObject, margin, trend, correlation, anisotropy, copula)
## make predictions at unobserved locations
predictions <- bayescopula(intamapExampleObject, estimates, search = 25,
                           calc = list(mean = TRUE, variance = TRUE, excprob = 40, quantile = 0.95))
## End(Not run)
```

createIntamapObject

Create an object for interpolation within the intamap package

Description

This is a help function for creating an object (see `intamap-package` to be used for interpolation within the intamap-package

Usage

```r
createIntamapObject(observations, obsChar, formulaString,
                    predictionLocations=100, targetCRS, boundaries, boundaryLines,
                    intCRS, params=list(), boundFile, lineFile, class="idw",
                    outputWhat, blockWhat = "none",...)
```
Arguments

observations  a SpatialPointsDataFrame, SpatialPixelsDataFrame, SpatialGridDataFrame, SpatialLinesDataFrame or SpatialPolygonsDataFrame with observations. Note that there are only few methods that can actually handle interpolation of observations with a support.

obsChar list with observation characteristics, used by some interpolation methods.

formulaString  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 universal kriging, suppose z is linearly dependent on x and y, use the formula z ~ x + y. The formulaString defaults to "value ~ 1" if value is a part of the data set. If not, the first column of the data set is used.

predictionLocations either a Spatial* object with prediction locations or an integer with the requested number of prediction locations. If boundaries are supported, the sampled prediction locations will be sampled within the boundaries.

targetCRS the wanted projection for the interpolated map.

boundaries  SpatialPolygonsDataFrame with the boundaries of regions in the prediction region.

boundaryLines SpatialPointsDataFrame with the boundaries between pairs of regions discretized as points. Will be read from file if lineFile is given or will be created from boundaries if not.

intCRS a particular projection requested for the interpolation.

params parameters for the interpolation, given as exceptions to the default parameters set in the function getIntamapParams. It is also possible to pass a methodParameters from an earlier call, as defined from the function methodParameters.

boundFile Filename where boundaries can be found, e.g. a shapefile.

lineFile Filename where paired points on boundaries can be found.

class setting the class(es) of the object, see intamap-package.

outputWhat List defining the requested type of output. Parameters:

mean = TRUE Usual kriging prediction
variance = TRUE Usual kriging error
quantile The estimated quantile for a certain threshold
excprob Exceedance probability for a certain threshold
cumdist The cumulative distribution for a certain value

MOK Assumed unbiased prediction using the MOK method for the threshold given. See unbiasedKrige

IWQSEL Assumed unbiased prediction using the IWQSEL method for the threshold given. See unbiasedKrige

... Additional prediction types that do not exist in the default parameter set, particularly parameters necessary for new methods within the intamap-package.

The list defaults to list (mean = TRUE) for objects of class IDW and list(mean=TRUE, variance = TRUE) for all other objects.
blockWhat List defining particular output for block predictions. These include:

blockMax logical; whether to predict maximum within block, if block predictions

blockMin logical; whether to predict minimum within block, if block predictions

fat Prediction of area within block above a threshold \((\text{fat} = \text{threshold})\)

blockMaxVar logical; whether to predict the variance of the prediction of max within the block, similarly it is possible to set \(\text{blockMinVar} = \text{TRUE}\) and \(\text{fatVar} = \text{threshold}\)

...• Either: other elements that can be used by particular interpolation methods. These are added to the object as named elements.

• Or: elements that have been created in earlier calls to one of the functions in the intamap-package, and that are not supposed to change in the second call. By adding these elements to the object in createIntamapObject, they can be reused without having to re-estimate them. Typical examples are the elements created from a call to preProcess

Details

This function is a help function for creating an object (see intamap-package) for interpolation within the intamap-package. The function uses some default values if certain elements are not included.

If createIntamapObject is called without predictionLocations, or if a number is given, the function will sample a set of predictionLocations. These will be sampled from a regular grid.

targetCRS and intCRS are not mandatory variables, but are recommended if the user wants predictions of a certain projection. intCRS is not necessary if the targetCRS is given and has a projection (is not lat-long). It is recommended to include the argument intCRS if all projected elements are lat-long, as many of the interpolation methods do not work optimal with lat-long data.

The ...-argument can be used for arguments necessary for new methods not being a part of the intamap-package. It is also a method for reusing previously calculated elements that can be assumed to be unchanged for the second interpolation.

Value

An object with observations, prediction locations, parameters and possible additional elements for automatic interpolation. The object will have class equal to the value of argument class, and methods in the intamap-package will dispatch on the object according to this class.

Author(s)

Jon Olav Skoien

References

estimateAnisotropy

See Also

intamap-package and getIntamapParams

Examples

# set up data:
data(meuse)
coordinates(meuse) = ~x+y
meuse$value = log(meuse$zinc)
data(meuse.grid)
gridded(meuse.grid) = ~x+y
proj4string(meuse) = CRS("+init=epsg:28992")
proj4string(meuse.grid) = CRS("+init=epsg:28992")

# set up intamap object:
idwObject = createIntamapObject(
  observations = meuse,
predictionLocations = meuse.grid,
targetCRS = "+init=epsg:3035",
class = "idw"
)

Description

This function estimates geometric anisotropy parameters for 2-D scattered data using the CTI method.

Usage

estimateAnisotropy(object, depVar, formulaString)

Arguments

object (i) An Intamap type object (see intamap-package) containing one SpatialPointsDataFrame data frame named observations which includes the observed values (ii) or a SpatialPointsDataFrame which includes both coordinates and observations.
depVar name of the dependent variable; this is used only in case (ii).
formulaString formula that defines the dependent variable as a linear model of independent variables, only used for case (ii); suppose the dependent variable has name z, for ordinary and simple kriging use the formula z~1; for universal kriging, suppose z is linearly dependent on x and y, use the formula z~x+y. The formulaString defaults to "value~1" if value is a part of the data set. If not, the first column of the data set is used.
Details

Given the input object that defines N coordinate pairs (x,y) and observed values (z), this method estimates of the geometric anisotropy parameters. Geometric anisotropy is a statistical property, which implies that the iso-level contours of the covariance function are elliptical. In this case the anisotropy is determined from the anisotropic ratio (R) and the orientation angle (θ) of the ellipse.

Assuming a Cartesian coordinate system of axes x and y, θ represents the angle between the horizontal axis and PA1, where PA1 is one of the principal axes of the ellipse, arbitrarily selected (PA2 will denote the other axis). R represents the ratio of the correlation along PA1 divided by the correlation length PA2. Note that the returned value of R is always greater than one (see value below.)

The estimation is based on the Covariance Tensor Identity (CTI) method. In CTI, the Hessian matrix of the covariance function is estimated from sample derivatives. The anisotropy parameters are estimated by explicit solutions of nonlinear equations that link (R,θ) with ratios of the covariance Hessian matrix elements.

To estimate the sample derivatives from scattered data, a background square lattice is used. The lattice extends in the horizontal direction from x.min to x.max where x.min (x.max) is equal to the minimum (maximum) x-coordinate of the data, and similarly in the vertical direction. The cell step in each direction is equal to the length of the lattice to the respective direction divided by the square root of N.

BiLinear interpolation, as implemented in akima package, is used to interpolate the field’s z values at the nodes of the lattice.

The CTI method is described in detail in (Chorti and Hristopulos, 2008).

Note that to be compatible with gstat the returned estimate of the anisotropy ratio is always greater than 1.

For observations assumed to have a trend, the trend is first subtracted from the data using universal kriging. This is an approximation, as the trend subtraction does not take anisotropy into account.

Value

(i) If the input is an Intamap object, the value is a modification of the input object, containing a list element anisPar with the estimated anisotropy parameters. (ii)if the input is a SpatialPointsDataFrame, then only the list anisPar is returned. The list anisPar contains the following elements:

- **ratio**: The estimate of the anisotropy ratio parameter. Using the degeneracy of the anisotropy under simultaneous ratio inversion and axis rotation transformations, the returned value of the ratio is always greater than 1.

- **direction**: The estimate of the anisotropy orientation angle. It returns the angle between the major anisotropy axis and the horizontal axis, and its value is in the interval (-90,90) degrees.

- **Q**: A 3x1 array containing the sample estimates of the diagonal and off-diagonal elements (Q11,Q22,Q12) of the covariance Hessian matrix evaluated at zero lag.

- **doRotation**: Boolean value indicating if the estimated anisotropy is statistically significant. This value is based on a statistical test of the isotropic (R= 1) hypothesis using a non-parametric approximation for the 95 percent confidence interval for R. This
approximation leads to conservative (wider than the true) estimates of the confidence interval. If doRotation==TRUE then an isotropy restoring transformation (rotation and rescaling) is performed on the coordinates. If doRotation==FALSE no action is taken.

Note

This function uses akima package to perform "bilinear" interpolation. The source code also allows other interpolation methods, but this option is not available when the function is called from within INTAMAP.

In the gstat package, the anisotropy ratio is defined in the interval (0,1) and the orientation angle is the angle between the vertical axis and the major anisotropy axis, measured in the clockwise direction. If one wants to use ordinary kriging inside INTAMAP the necessary transformations are performed in the function estimateParameters.automap. If one wants to use ordinary kriging in the gstat package (but outside INTAMAP) the required transformations can be found in the source code of the estimateParameters.automap function.

Author(s)

A.Chorti, D.T.Hristopulos, G. Spiliopoulos

References


Examples

```r
library(gstat)
data(sic2004)
coordinates(sic.val)=~x+y
sic.val$value=sic.val$dayx
params=NULL

estimateAnisotropy(sic.val,depVar = "joker")
```
estimateParameters

Automatic estimation of correlation structure parameters

Description

Function to estimate correlation structure parameters. The actual parameters depend on the method used.

Usage

## S3 method for class ‘automap’
estimateParameters(object, ... )
## S3 method for class ‘copula’
estimateParameters(object, ... )
## Default S3 method:
estimateParameters(object, ... )
## S3 method for class ‘idw’
estimateParameters(object, ... )
## S3 method for class ‘linearVariogram’
estimateParameters(object, ... )

## S3 method for class ‘transGaussian’
estimateParameters(object, ... )
## S3 method for class ‘yamamoto’
estimateParameters(object, ... )

Arguments

object an intamap object of the type described in intamap-package
...
other arguments that will be passed to the requested interpolation method. See the individual methods for more information. Some parameters that are particular for some methods:

idpRange range of idp (inverse distance weighting power) values over which to optimize mse (idw-method)
nfolds number of folds in n-fold cross validation (idw-method)
lambda lambda parameter for boxcox-transformation (transGaussian method)
significant logical; if TRUE only transform if any of the four tests described under interpolate are TRUE (transGaussian method)

Details

The function estimateParameters is a wrapper around different methods for estimating correlation parameters to be used for the spatial prediction method spatialPredict. Below are some details about and/or links to the different methods currently implemented in the intamap-package.
It is possible but not necessary to estimate variogram parameters for this method. If `estimateParameters` is called with an object of class `automap`, `autofitVariogram` will be called. If object already includes a variogram model when `spatialPredict` is called, `krige` in the `gstat`-package will be called directly. The user can submit an argument `model` with the model(s) to be fitted.

Finding the best copula parameters using `copulaEstimation`.

A default method is not really implemented, this function is only created to give a sensible error message if the function is called with an object for which no method exist.

Fits the best possible idw-power to the data set by brute force searching within the `idpRange`.

This function just returns the original data, no parameter fitting is necessary for linear variogram kriging.

Finding the best model parameters for transGaussian kriging (`krigeTg`). This means finding the best lambda for the `boxcox`-transformation and the fitted variogram parameters for the transformed variable. If `significant = TRUE` will lambda only be estimated if the data show some deviation from normality, i.e., that at least one of the tests described under `interpolate` is `TRUE`. Note that transGaussian kriging is only possible for data with strictly positive values.

A wrapper around `estimateParameters.automap`, only to assure that there is a method also for this class, difference to `automap` is more important in `spatialPredict`.

It is also possible to add to the above methods with functionality from other packages, if wanted. You can also check which methods are available from other packages by calling

```
> methods(estimateParameters)
```

Value

A list object similar to `object`, but extended with correlation parameters.

Author(s)

Jon Olav Skoien

References

Examples

```r
set.seed(13131)

# set up data:
data(meuse)
coordinates(meuse) = ~x+y
meuse$value = log(meuse$zinc)
data(meuse.grid)
gridded(meuse.grid) = ~x+y
proj4string(meuse) = CRS("+init=epsg:28992")
proj4string(meuse.grid) = CRS("+init=epsg:28992")

# set up intamap object:
idwObject = createIntamapObject(
  observations = meuse,
  formulaString=as.formula(zinc~1),
  predictionLocations = meuse.grid,
  class = "idw"
)

# run test:
checkSetup(idwObject)

# do interpolation steps:
idwObject = estimateParameters(idwObject, idpRange = seq(0.25,2.75,.25),
  nfold=3) # faster
idwObject$inverseDistancePower
```

estimateTimeModel

Description

Function that takes time samples function that can read intamap objects

Usage

```r
estimateTimeModel(FUN, class, formulaString, debug.level, ...)
```

Arguments

- **FUN**: A string with function’s name
- **class**: class of intamapObject, which interpolation method to be used.
- **formulaString**: the formula of the request, mainly to see if the request has independent variables.
- **debug.level**: if debug.level >= 1, the function will store tables with the prediction times for each model in the workspace.
- **...**: other arguments as defined in the `createIntamapObject` function
generateTimeModels

Details

This function uses createIntamapObject function to create synthetic data, in order to take time samples for the function with string name "FUN". The calculated model is stored, as an element of a list, in a local file (workspace for now) and it’s used in order to give quick time estimates.

Value

The function does not return a variable but stores the result in an element list with the same name.

References


---

generateTimeModels Generate time models

Description

function that generates time models and saves them in workspace.

Usage

generateTimeModels(genClasses = NULL, noGenClasses = NULL, nSam = 1, test = FALSE, debug.level = 0)

Arguments

genClasses list of particular classes for which time models should be generated
noGenClasses list of particular classes for which time models should not be generated
nSam number of attempts to be tried for each combination of predictions and observations, defaults to 1, higher number should be used for better accuracy. nSam/2 is used for copulas, to reduce computation time.
test logical; if true, the time models are generated based on fewer iterations, for speed
debug.level if debug.level >= 1, the function will store tables with the prediction times for each model in the workspace.
**Details**

This function calculates a time model for different interpolation types in the *intamap-package* and returns a list object with the estimated models. It's users responsibility to store the model in the workspace. The normal procedure would be to run the function without arguments. However, it is both possible to define a list for which classes the user want to generate models, or a list of classes that are not of interest.

The time model is based on creation of a set of synthetical data sets of different size, both regarding number of observations and prediction locations. The function will estimate parameters and make predictions with the different combinations, and for each method, fit a local polynomial regression model (*loess*)

This model can then be used by *predictTime* to estimate the prediction time for an interpolation request with a certain number of observations and prediction locations.

**Value**

The function generates a `timeModels` object, which can be used to estimate prediction times for different requests to the *interpolate* function in the *intamap-package*, via *predictTime*.

**References**


**Examples**

```r
## Not run:
timeModels=generateTimeModels()
q("yes")
## restart R in the same directory

## End(Not run)
```

---

**getIntamapParams**

**Setting parameters for the intamap package**

**Description**

This function sets a range of the parameters for the *intamap-package*, to be included in the object described in *intamap-package*.

**Usage**

```
getIntamapParams(oldPar,newPar,...)
```
getIntamapParams

Arguments

oldPar  An existing set of parameters for the interpolation process, of class IntamapParams or a list of parameters for modification of the default parameters
newPar  A list of parameters for updating oldPar or for modification of the default parameters. Possible parameters with their defaults are given below

...  Individual parameters for updating oldPar or for modification of the default parameters. Possible parameters with their defaults are given below
doAnisotropy = FALSE Defining whether anisotropy should be calculated
removeBias = NA Defining whether biases should be removed, and in case yes, which ones (localBias and regionalBias implemented
addBias = NA Defining which biases to be added in the postProcess function. This has not yet been implemented.
biasRemovalMethod = "LM" character; specifies which methods to use to remove bias. See below.
doSegmentation = FALSE Defining if the predictions should be subject to segmentation. Segmentation has been implemented, but not the use of it.
testMean logical; for copula method only; whether or not the predictive means (if calculated) should be tested for being reasonable
nmax = 50 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, 50 observations are used.
maxdist = Inf for local kriging: Maximum distance to neighbouring locations to be used in kriging or simulations
ngrid = 100 The number of grid points to be used if an Averaged Cumulative Distribution Function (ACDF) needs to be computed for unbiased kriging
nsim=100 Number of simulations when needed
block = numeric(0) 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.gstat. By default, predictions or simulations refer to the support of the data values.
processType = "gaussian" If known - the distribution of the data. Defaults to gaussian, analytical solutions also exists in some cases for logNormal. This setting only affects a limited number of methods, e.g. the block predicton
confProj = FALSE If set, the program will attempt conform projections in preProcess, calling the function conformProjections.
debug.level = 0 Used in some functions for giving additional output. See individual functions for more information.
nclus = 1 it is possible to use parallel processing for some interpolation methods (currently only the copula method), nclus defines the number of processes to spawn. This requires previous installation of the doParallel package
... Additional parameters that do not exist in the default parameter set, this could be parameters necessary for new methods within or outside the intamap-package
Value

A list of the parameters with class `intamapParams` to be included in the object described in `intamap-package`.

Note

This function will mainly be called by `createIntamapObject`, but can also be called by the user to create a parameter set or update an existing parameter set. If none of the arguments is a list of class `IntamapParams`, the function will assume that the argument(s) are modifications to the default set of parameters.

If the function is called with two lists of parameters (but the first one is not of class `IntamapParams`) they are both seen as modifications to the default parameter set. If they share some parameters, the parameter values from the second list will be applied.

Author(s)

Jon Olav Skoien

References


See Also

`createIntamapObject`

Examples

```r
# Create a new set of intamapParameters, with default parameters:
params = getIntamapParams()
# Make modifications to the default list of parameters
params = getIntamapParams(newPar=list(removeBias = "local",
                                      secondParameter = "second"))
# Make modifications to an existing list of parameters
params = getIntamapParams(oldPar = params,newPar = list(predictType = list(exc=TRUE)))
```

getInterpolationMethodNames

get interpolation method names

Description

get interpolation method names
Usage

getInterpolationMethodNames()

Details

none

Value

character array with names for available interpolation methods

Author(s)

Edzer Pebesma

References


Examples

getInterpolationMethodNames()

Example data for the intamap package

Description

Salted (slightly modified) observations from the European gamma radiation network

Usage

data(intamap)

Details

The data set is a salted data set from the European gamma radiation network https://remap.jrc.ec.europa.eu/GammaDoseRates.aspx. Salted does in this context mean that all locations and observation values have been randomized through addition of a random value.

References

intamapExampleObject  Simulated Intamap Object

Description

Intamap object of class "copula" containing a simulated data set with 196 spatial locations.

Usage

data(intamapExampleObject)

Details

The data set is a realization of a random field generated using a Gaussian copula and generalized extreme value distributed margins (location=40, shape=0.5, scale=30). The correlation function is Matern (Stein’s representation) with range=4, kappa=3 and nugget=0.05. Furthermore, there is geometric anisotropy with direction=pi/3 and ratio=2.

References


See Also

spatialPredict.copula, estimateParameters.copula

Examples

```r
# Not run:
data(intamapExampleObject)
# estimate parameters for the copula model
intamapExampleObject<-estimateParameters(intamapExampleObject)
# make predictions at unobserved locations
intamapExampleObject<-spatialCopula(intamapExampleObject)

# End(Not run)
```
interpolate

interpolate is a function that interpolates spatial data.

Usage

interpolate(observations, predictionLocations,
    outputWhat = list(mean = TRUE, variance = TRUE),
    obsChar = NA, methodName = "automatic", maximumTime = 30,
    optList = list(), cv = FALSE, ...)

interpolateBlock(observations, predictionLocations, outputWhat,
    blockWhat = "none", obsChar = NA, methodName = "automatic",
    maximumTime = 30,
    optList = list(), ...)

Arguments

observations observation data, object of class SpatialPointsDataFrame. The observation
to be interpolated has to be identified through the column name value

predictionLocations prediction locations, object of class SpatialPoints*, SpatialPixels* or SpatialGrid*,
or the number of predictionLocations to be sampled from the boundaries of the
observations

outputWhat list with names what kind of output is expected, e.g. outputWhat = list(mean=TRUE,variance=TRUE,
    nsim = 5)

blockWhat List defining particular output for block predictions. See createIntamapObject

obsChar list with observation characteristics, used by some interpolation methods

methodName name of interpolation method to be used, see spatialPredict for more details, or
automatic, to let the method be decided by the program, based on maximum-
Time and type of variables input

maximumTime the maximum time available for interpolation, will be compared to the result of
predictTime for the requested method, or for finding the best interpolation
method able to finish within this time

optList list; further options, mainly passed to createIntamapObject as the argument
params, directly as arguments, but some are used locally in interpolate and
interpolateBlock:

    formulaString passed as argument to createIntamapObject, if no formulaS-
       tring is given, it will default to value~1 if observations has a column
        named value or to col1 ~ 1 where col1 is the first column of the observ-
        ations

    set.seed the possibility to pass a seed value to interpolate, to assure repro-
       ducible results also for methods relying on random numbers
The functions `interpolate` and `interpolateBlock` are particularly implemented for being called by a Web Processing Server (WPS), but they can also be used interactively. The only necessary arguments are `observations` and `predictionLocations`. It is also recommended to set `outputWhat`, and `blockWhat` if necessary. If `outputWhat` contains `nsim`, the return table will also contain a number of realisations, for methods able to return simulations.

`interpolate` can use different interpolation methods for the result. The function will internally call the following functions which can be method specific.

- `preProcess`
- `estimateParameters`
- `spatialPredict`
- `postProcess`

An indication of available methods can be given by `methods(estimateParameters)` or `methods(spatialPredict)`. The method can be set through the argument `methodName`, or through the built-in automatic selection method. There are different criteria that helps in selecting the right method for a particular data set. There are four methods that are available for the automatic choice: `automap`, `psgp` (from the separate package `psgp`), `copula` and `transgaussian` are the possibilities. First of all, if observation errors are present, the `psgp` method is preferred. If not, it is checked whether the data appear to deviate significantly from normality. This is assumed to be the case if any of the tests below are TRUE:

\[
\begin{align*}
\text{test}[1] &= \frac{\text{length(boxplot.stats(dataObs)$out)}}{\text{length(dataObs)}} > 0.1 \\
\text{test}[2] &= \text{fivenum(dataObs)[3]} - \text{fivenum(dataObs)[2]} < \text{IQR(dataObs)}/3 \\
\text{test}[3] &= \text{fivenum(dataObs)[4]} - \text{fivenum(dataObs)[3]} < \text{IQR(dataObs)}/3 \\
g &= \text{boxcox(dataObs ~ 1,lambda=seq(-2.5,2.5,len=101),plotit=FALSE)}$y \\
\text{test}[4] &= g[71] < \text{sort(g)[91]}
\end{align*}
\]

where `fivenum` defines the Tukey five number statistic and `IQR` finds the interquartile range of the data. If the minimum of `dataObs` is \( <= 0 \), \( \min(dataObs) + \text{sdev(dataObs)} \) is added to all values.

At last, the function calls `predictTime` for an estimate of the prediction time. If any of the tests above were true and the estimated prediction time for copula prediction is below `maximumTime`, the copula method is chosen. If any of the tests were TRUE and the estimated prediction time is too long, `transGaussian` kriging is chosen, as long as all values are above zero. If any of the tests are true for a set of observations with negative or zero-values, `automap` is chosen, but a warning is issued.

The element `methodParameters` in the object being returned is a string that makes it possible to regenerate the variogram model or the copula parameters in `createIntamapObject`. This is particularly useful when the function is called through a WPS, when the element with the estimated
parameters cannot be preserved in a state that makes it possible to use them for a later call to \texttt{interpolate}.

The possibility for doing parallel processing is enabled for some of the main methods. To be able to take advantage of multiple CPUs on a computer, the package \texttt{doParallel} must be downloaded, additionally the parameter \texttt{nclus} must be set to a value larger than 1. Parallel computation is not taken into account when estimating the prediction times.

\textbf{Value}

An intamap object, which is a list with elements, see \texttt{intamap-package}. The exact number and names of these elements might vary due to different methods applied, but the list below shows the most typical:

\begin{itemize}
  \item [observations] the observations, as a \texttt{Spatial*DataFrame}
  \item [predictionLocations] the prediction locations, as a \texttt{Spatial-object}
  \item [formulaString] the relationship between independent and dependent variables, value or obs used if not given
  \item [outputWhat] a list of the prediction types to return
  \item [anisPar] the estimated anisotropy parameters
  \item [variogramModel] the estimated parameter for the method, can also be e.g. \texttt{copulaParams} for the copula method or \texttt{inverseDistancePower} for inverse distance power method.
  \item [methodParameters] a string, that when parsed, can be used to regenerate the variogram model or copula parameters. Useful for repeated calls to interpolate when it is not necessary to reestimate the parameters.
  \item [predictions] a \texttt{Spatial*DataFrame} with predictions, for most methods with a format equal to the output from \texttt{krige} with predicted mean and variance as \texttt{var1.pred} and \texttt{var1.var}
  \item [outputTable] a matrix, organized in a convenient way for the calling WPS; first row: x-coordinates, second row: y-coordinates; further rows: output elements as specified by \texttt{outputWhat}
  \item [processDescription] some textual descriptions of the interpolation process, including warnings
\end{itemize}

\textbf{Author(s)}

Edzer Pebesma

\textbf{References}


\textbf{See Also}

\texttt{createIntamapObject, estimateParameters, spatialPredict, intamap-package}
Examples

```r
data(meuse)
coordinates(meuse) = ~x+y
meuse$value = meuse$zinc
data(meuse.grid)
gridded(meuse.grid) = ~x+y
x = interpolate(meuse, meuse.grid, list(mean=TRUE, variance=TRUE))
summary(t(x$outputTable))
```

Description

function that generates a parsable string of identified method parameters for an intamap interpolation object

Usage

```r
## Default S3 method:
methodParameters(object)
## S3 method for class 'copula'
methodParameters(object)
## S3 method for class 'idw'
methodParameters(object)
```

Arguments

- `object`: a list object. Most arguments necessary for interpolation are passed through this object. See `intamap-package` for further description of the necessary content of this variable

Details

The function creates a text-string that makes it possible to add the the method parameters (anisotropy and idw-parameter, variogram model or copula parameters) to the object in a later call to `createIntamapObject` or `interpolate` without having to re-estimate the parameters. This function is particularly useful when `interpolate` is called from a Web Processing Service, and the user wants to reuse the method parameters. The function is mainly assumed to be called from within `interpolate`.

The default method assumes a variogram model of `gstat` type, e.g. a variogram similar to what can be created with a call to `vgm`. Also `psgp` uses this variogram model.

Value

A string that, when parsed, will recreate the `methodParameters`
plotIntamap

Author(s)
Jon Olav Skoien

References

Examples

```r
sessionInfo()
data(meuse)
coordinates(meuse) = ~x+y
meuse$value = log(meuse$zinc)
# set up intamap object:
krigingObject = createIntamapObject(
  observations = meuse,
  formulaString = as.formula('value~1'),class = "automap")
# do estimation steps:
krigingObject = estimateParameters(krigingObject)
krigingObject = methodParameters(krigingObject)

# Create a new object
krigingObject2 = createIntamapObject(observations = meuse,
  formulaString = as.formula('value~1'),
  params = list(methodParameters = krigingObject$methodParameters))

krigingObject$variogramModel
krigingObject2$variogramModel
```

Description
Plotting function for intamap-objects of the type described in intamap-package

Usage

```r
plotIntamap(object, zcol = "all", sp.layout = NULL, plotMat = c(2,2), ...)
## S3 method for class 'copula'
plot(x, ...)
## S3 method for class 'idw'
plot(x, ...)
## S3 method for class 'automap'
plot(x, ...)
```
## S3 method for class 'linearVariogram'
plot(x, ...)

## S3 method for class 'transGaussian'
plot(x, ...)

## S3 method for class 'yamamoto'
plot(x, ...)

### Arguments
- **object**: a list object. Most arguments necessary for interpolation are passed through this object. See `intamap-package` for further description of the necessary content of this variable.
- **x**: intamap object, when plot is called directly.
- **zcol**: a list of column names to be plotted; if equal to all, the column names will correspond to all possible column names from `outputWhat` (see `createIntamapObject`).
- **sp.layout**: an object that can contain lines, points and polygons that function as extra layout; see `spplot` for more information.
- **plotMat**: an array of length two with the number of rows and columns of plots per page.
- **...**: other parameters that can be passed to other plot functions (e.g. `plot`, `spplot`, `automapPlot` and `xyplot`).

### Details
All the plot methods above are simple wrapper functions around the `plotIntamap` function.

### Value
A plot of some of the elements of `object`. This will typically be the sample variogram and the fitted variogram model (if a method based on variograms has been used) and all the predictions.

### Author(s)
Jon Olav Skoien

### References

### Examples
```r
data(meuse)
meuse$value = log(meuse$zinc)
data(meuse.grid)
coordinates(meuse) = ~x+y
coordinates(meuse.grid) = ~x+y
object = interpolate(meuse, meuse.grid,
```
Description

post-processing of data for the `intamap-package`. The function will typically call other functions for adding back biases, aggregation etc.

Usage

```r
## Default S3 method:
postProcess(object, ...)
## S3 method for class 'idw'
postProcess(object, ...)
```

Arguments

- `object` a list object. Most arguments necessary for interpolation are passed through this object. See `intamap-package` for further description of the necessary content of this variable
- `...` other parameters that can be passed to functions called from `preProcess`

Details

The function `postProcess` includes code for postprocessing an object after interpolation. The function can easily be replaced by more specific methods relevant for a certain data set, doing more data specific things in addition to what is done in the default method.

Value

An object of same type as above, but with new elements. Most important from the default method is the `outputTable`, a matrix, organized in a convenient way for the calling WPS: first row: x-coordinates, second row: y-coordinates; further rows: output elements as specified by `outputWhat` (see `createIntamapObject`)

Author(s)

Edzer J. Pebesma

References

### predictTime

*Time prediction for intamap package methods*

**Description**

Functions that give a time estimate for an intamap function given the number of observations and prediction locations.

**Usage**

```r
predictTime(nObs, nPred, class, formulaString, calibration=FALSE,
outputWhat, FUN = "spatialPredict",...)
```

**Arguments**

- `nObs`: An integer or an array of integers containing the number of observations.
- `nPred`: An integer or an array of integers containing the number of predictions.
- `class`: Class of intamapObject, which interpolation method to be used.
- `formulaString`: The formula of the request, mainly to see if the request has independent variables.
- `calibration`: Enables or disables time calibration - not properly implemented yet.
- `outputWhat`: List defining the requested type of output, see `createIntamapObject`.
- `FUN`: A string with the intamap functions name, now obsolete.
- `...`: Other arguments needed to define the intamap object.

**Details**

The function is based on `timeModels` being available in the workspace. This is a loess-model that has been fitted to different calls to a range of interpolation requests with synthetically generated data in `generateTimeModels`.

**Value**

An integer or an array of integers with the predicted times.

**Note**

RUN FIRST `generateTimeModels()` or `estimateTimeModel()` in order to save time Models to workspace. It might take some time!

**References**

Description

pre-processing of the data for the *intamap-package* package.

Usage

```r
## Default S3 method:
preProcess(object, ...)
## S3 method for class 'idw'
preProcess(object, ...)
```

Arguments

- **object** see *intamap-package*; list that should at least contain (i) an element called observations of class *SpatialPointsDataFrame*. The measured values should be named value, and (ii) an element params of class list, by calling the function *getIntamapParams*. (iii) Usually, the object will also contain an element called predictionLocations, of a class extending *Spatial*.

- ... Additional parameters

Details

The function `preProcess` includes code for preprocessing an object before interpolation. The function can easily be replaced by more specific methods relevant for a certain data set. Functions can be called from `preProcess` according to the settings in parameters in the object, set by the function `getIntamapParams`.

Value

The input object is returned, after its components have been pre-processed.

Author(s)

Jon Olav Skoien

References

rotateAnisotropicData

Description
This function applies an isotropic transformation of the coordinates specified in object.

Usage
rotateAnisotropicData(object, anisPar)

Arguments
object (i) An Intamap type object (see intamap-package) containing one SpatialPointsDataFrame data frame named observations which includes the observed values (ii) or a SpatialPointsDataFrame which includes both coordinates and observations or (iii) SpatialPoints which includes only coordinates to be rotated.

anisPar An array containing the anisotropy parameters (anisotropy ratio and axes orientation) (see estimateAnisotropy) for the rotation. If object is the output of estimateAnisotropy function, these parameters are part of object. In cases (ii) and (iii) anisPar defines the two anisotropy parameters. For the definition of the anisotropy parameters see estimateAnisotropy.

Details
This function performs a rotation and rescaling of the coordinate axes in order to obtain a new coordinate system, in which the observations become statistically isotropic. This assumes that the estimates of the anisotropy ratio and the orientation angle provided in anisPar are accurate.

Value
(i) A modified object with transformed coordinates if rotateAnisotropicData is called with an Intamap object as input (see intamap-package) or (ii) the transformed coordinates if a SpatialPointsDataFrame is used as input or (iii) the transformed coordinates if a SpatialPoints object is the input.

Author(s)
Hristopulos Dionisis, Spiliopoulos Giannis

References

spatialPredict

See Also

estimateAnisotropy

Examples

```r
library(gstat)
data(sic2004)
coordinates(sic.val)=~x+y
sic.val$value=sic.val$dayX

anisPar <- estimateAnisotropy(sic.val)
print(anisPar)

rotatedObs <- rotateAnisotropicData(sic.val,anisPar)

newAnisPar <- estimateAnisotropy(rotatedObs)
print(newAnisPar)
```

descriptions

spatialPredict is a generic method for spatial predictions within the intamap-package. A series of methods have been implemented, partly based on other R-packages (as kgrid), other methods have been developed particularly for the INTAMAP project. The object has to include a range of variables, further described in intamap-package. The prediction method is chosen based on the class of the object.

Usage

```r
## S3 method for class 'automap'
spatialPredict(object, nsim = 0, ...)

## S3 method for class 'copula'
spatialPredict(object, ...)

## Default S3 method:
spatialPredict(object, ...)

## S3 method for class 'idw'
spatialPredict(object, ...)

## S3 method for class 'linearVariogram'
spatialPredict(object, nsim = 0, ...)

## S3 method for class 'transGaussian'
spatialPredict(object, nsim = 0, ...)

## S3 method for class 'yamamoto'
spatialPredict(object, nsim = 0, ...)
```
Arguments

- **object**: a list object. Most arguments necessary for interpolation are passed through this object. See `intamap-package` for further description of the necessary content of this variable.
- **nsim**: number of simulations to return, for methods able to return simulations.
- **...**: other arguments that will be passed to the requested interpolation method. See the individual interpolation methods for more information.

Details

The function `spatialPredict` is a wrapper around different spatial interpolation methods found within the `intamap-package` or within other packages in R. It is for most of the methods necessary to have parameters of the correlation structure included in `object` to be able to carry out the spatial prediction. Below are some details about particular interpolation methods:

- **default**: a default method is not really implemented, this function is only created to give a sensible error message if the function is called with an object for which no method exist.
- **automap**: If the object already has an element `variogramModel` with variogram parameters, `krige` is called. If the this is not a part of the object, `estimateParameters` is called to create this element.

- **copula**: spatial prediction using `bayesCopula`.
- **idw**: applies inverse distance modelling with the idp-power found by `estimateParameters.idw`.
- **linearVariogram**: this function estimates the process using an unfitted linear variogram; although variance is returned it can not be relied upon.
- **transGaussian**: spatial prediction using `krigeTg`.
- **yamamoto**: spatial prediction using `yamamotoKrige`.

It is also possible to add to the above methods with functionality from other packages, if wanted. You can also check which methods are available from other packages by calling `>methods(spatialPredict)`.

Value

A list object similar to `object`, but extended with predictions at a the set of locations defined `object`.

Author(s)

Jon Olav Skoien

References


See Also

`gstat`, `autoKrigge`, `createIntamapObject`, `estimateParameters`, `intamap-package`
### Examples

# This example skips some steps that might be necessary for more complicated
# tasks, such as estimateParameters and pre- and postProcessing of the data
data(meuse)
coordinates(meuse) = ~x+y
meuse$value = log(meuse$zinc)
data(meuse.grid)
gridded(meuse.grid) = ~x+y
proj4string(meuse) = CRS("+init=epsg:28992")
proj4string(meuse.grid) = CRS("+init=epsg:28992")

# set up intamap object:
obj = createIntamapObject(
  observations = meuse,
predictionLocations = meuse.grid,
targetCRS = "+init=epsg:3035",
params = getIntamapParams(),
class = "linearVariogram"
)

# do interpolation step:
obj = spatialPredict(obj)  # spatialPredict.linearVariogram

---

**summaryIntamap**  
**summary intamap objects**

### Description

summary function for intamap-objects of the type described in intamap-package

### Usage

```r
summaryIntamap(object, ...)
## S3 method for class 'copula'
summary(object, ...)
## S3 method for class 'idw'
summary(object, ...)
## S3 method for class 'automap'
summary(object, ...)

## S3 method for class 'linearVariogram'
summary(object, ...)
## S3 method for class 'transGaussian'
summary(object, ...)
## S3 method for class 'yamamoto'
summary(object, ...)
```
Arguments

object  
a list object. Most arguments necessary for interpolation are passed through this object. See \texttt{intamap-package} for further description of the necessary content of this variable

parameters to be passed to the default summary function for each element

Value

A summary of some of the elements of \texttt{object}.

Author(s)

Jon Olav Skoien

References


\begin{verbatim}
timeModels                      models for estimating prediction time in intamap package
\end{verbatim}

Description

This is a standard model for estimating the prediction time within the \texttt{intamap-package}. It was created by the function \texttt{generateTimeModels}, on a 64 bits Linux server running \texttt{R} version 2.9.0 and \texttt{intamap-package} version 1.1.15.

The prediction time will depend on the speed of the local machine, on the version of \texttt{R} and \texttt{intamap-package}, and on the installed libraries. It is therefore strongly recommended to run \texttt{generateTimeModels} on the local machine and store the result in the workspace if the predicted interpolation time is of real interest. \texttt{timeModels} in the workspace will be chosen if available.

It is not necessary to load the data set, this happens automatically in \texttt{predictTime} if \texttt{timeModels} if the object is not already existing in the workspace.

Usage

data(timeModels)

Author(s)

Jon Olav Skoien

References

Description

unbiasedKrig is a function for modifying a kriging prediction to a prediction that can be assumed to be unbiased for a certain threshold.

Usage

unbiasedKrig(object, formulaString, observations, predictionLocations, model, outputWhat, yamamoto, iwqmaxit = 500, iwqCpAddLim = 0.0001, debug.level, ...)

Arguments

object
either an object of the intamap type (see intamap-package for further description of the necessary content of this variable) or the output from the function krig in gstat. If the object is a result from the intamap procedure spatialPredict, the remaining arguments are not necessary.

formulaString
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 universal kriging, suppose z is linearly dependent on x and y, use the formula z~x+y

observations
a Spatial*DataFrame with observations; should contain the dependent variable, independent variables, and coordinates

predictionLocations
the predictionLocations, only necessary if the method is "IWQSEL" and formulaString contains independent variables. Should preferentially be a grid if the method is "IWQSEL"

model
variogram model of dependent variable (or its residuals), defined by a call to vgm or autofitVariogram

outputWhat
Argument with type of unbiasedness method ("MOK" or "IWQSEL") and the thresholds.

yamamoto
logical describing if the yamamoto approach is to be used in simulations. Defaults to yamamoto = FALSE when object is a Spatial*DataFrame.

iwqmaxit
maximum number of iterations in iwqsel

iwqCpAddLim
convergence criteria in iwqsel

d debug.level
d debug level, passed to subfunctions

... other arguments that will be passed to subfunctions. These include

nsim number of simulations necessary if the method is "IWQSEL". Defaults to nsim = 100 when object is a Spatial*DataFrame.
mmaxdist maximum number of neighbours to use in local kriging, defaults to Inf

nmax for local kriging: the number of nearest observations that should be used in simulations for the "IWQSEL" method in terms of the space of the spatial locations. Defaults to nmax = 10 when object is a Spatial*DataFrame.
unbiasedKriging

Details

It is a fact that predictions from kriging tend to be biased towards the mean of the process. The function unbiasedKriging is a function that adds one or more predictions to the original output, which are assumed to be unbiased relative to a certain threshold. The two methods supported are the IWQSEL-method (Craigmile, 2006) and MOK (Skoien et al, 2008).

Value

an object of type intamap, as described in intamap-package, or a Spatial*DataFrame with one or more new prediction columns, representing different methods and thresholds.

Author(s)

Jon Olav Skoien

References


Examples

```r
library(automap)
library(gstat)
data(meuse)
data(meuse.grid)
coordinates(meuse) = ~x+y
gridded(meuse.grid) = ~x+y

predictionLocations = meuse.grid[sample(1:length(meuse.grid),50),]
vm = autovarogram(log(zinc)~1,meuse)$var_model
prediction = krige(log(zinc)~1,meuse,predictionLocations,vm)
summary(prediction)

prediction <- unbiasedKriging(prediction,log(zinc)~1,
                             meuse, model = vm, outputWhat = list(MOK = 6.0, MOK = 7.0, IWQSEL=7.0),
                             iwqmaxit = 100, iwqCpAddLim = 0.01)
summary(prediction)
```
yamamotoKriging

kriging and simulation with alternative kriging variance

Description
ordinary kriging and simulation with an alternative kriging variance

Usage
yamamotoKriging(formula, Obs, newPoints, model, nsim = 0, nmax = 20, maxdist = Inf)

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; only ordinary kriging is currently implemented, formula is hence mainly used to identify the dependent variable

Obs          SpatialPointsDataFrame with observations

newPoints    Spatial object with prediction locations, either points or grid

model        variogram model - of the type that can be found by a call to vgm

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

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.

maxdist      maximum number of neighbours to use in local kriging, defaults to Inf

Details
The term yamamotoKriging comes from the paper of Yamamoto (2000) where he suggests using local variance around the kriging estimate (weighted with the kriging weights) as an alternative kriging variance. This as a solution to more reliable estimates of the kriging variance also when the stationarity assumption has been violated. The method was applied by Skoien et al. (2008), who showed that it can have advantages for cases where the stationarity assumption behind kriging is violated.

If the number of observations is high, it is recommended have nmax lower. This is partly because the method relies on positive kriging weights. The method to do this adds the norm of the largest negative weight to all weights, and rescales. This tends to smooth the weights, giving a prediction closer to the average if a too large number of observation locations is used.

Value
Either a Spatial*DataFrame with predictions and prediction variance, in the columns var1.pred and var1.var, together with the classical ordinary kriging variance in var1.ok, or simulations with column names simx where x is the number of the simulation.
Author(s)

Jon Olav Skoien

References


Examples

```r
library(gstat)
library(automap)
data(sic2004)
coordinates(sic.val) = ~x+y
coordinates(sic.test) = ~x+y
variogramModel = autofitVariogram(joker~1,sic.val)$var_model
newData = yamamotoKrige(joker~1,sic.val,sic.test,variogramModel,nmax = 20)
summary(newData)
plot(sqrt(var1.ok)~var1.pred,newData)
# Kriging variance the same in regions with extreme values
plot(sqrt(var1.var)~var1.pred,newData)
# Kriging standard deviation higher for high predictions (close to extreme values)
```
# Index

* **datasets**
  - intamap, 29
  - intamapExampleObject, 30
* **htest**
  - estimateAnisotropy, 19
* **nonparametric**
  - estimateAnisotropy, 19
* **spatial**
  - bayesCopula, 6
  - blockPredict, 8
  - checkSetup, 10
  - coarsenGrid, 11
  - conformProjections, 12
  - copulaEstimation, 14
  - createIntamapObject, 16
  - estimateAnisotropy, 19
  - estimateParameters, 22
  - estimateTimeModel, 24
  - generateTimeModels, 25
  - getIntamapParams, 26
  - getInterpolationMethodNames, 28
  - intamap-package, 2
  - interpolate, 22
  - methodParameters, 34
  - plotIntamap, 35
  - postProcess, 37
  - preProcess, 39
  - rotateAnisotropicData, 40
  - spatialPredict, 41
  - summaryIntamap, 43
  - unbiasedKrige, 45
  - yamamotoKrige, 47

* autofitVariogram, 23, 45
* autoKrigc, 9, 42
* automapPlot, 36

* bayesCopula, 6, 16, 42
* blockPredict, 8
* boxcox, 22, 23

* checkSetup, 10
* coarsenGrid, 11
* conformProjections, 6, 12, 27
* copulaEstimation, 6, 7, 14, 23
* createIntamapObject, 12, 16, 23, 24, 28, 31–34, 36–38, 42
* estimateAnisotropy, 19, 40
* estimateParameters, 7, 16, 22, 32, 33, 42
* estimateParameters.copula, 30
* estimateTimeModel, 24

* fivenum, 32
* generateTimeModels, 25, 38, 44
* getIntamapParams, 5, 17, 19, 26, 39
* getInterpolationMethodNames, 28
* gstat, 9, 42, 45
* intamap, 29
* intamap-package, 2
* intamapExampleObject, 30
* interpolate, 22, 23, 26, 31, 34
* interpolateBlock (interpolate), 31
* IQR, 32
* krigc, 9, 23, 33, 41, 42, 45
* krigcTg, 23, 42
* loess, 26, 38
* methodParameters, 17, 32, 34
* observations (intamap), 29
* optim, 15

* plot, 36
* plot.automap (plotIntamap), 35
* plot.copula (plotIntamap), 35
* plot.default (plotIntamap), 35
* plot.idw (plotIntamap), 35
plot.linearVariogram(plotIntamap), 35
plot.transGaussian(plotIntamap), 35
plot.yamamoto(plotIntamap), 35
plotIntamap, 35
postProcess, 5, 27, 32, 37
predict.gstat, 5, 8, 27
predictTime, 26, 31, 32, 38
preProcess, 6, 10, 18, 27, 32, 39
rotateAnisotropicData, 40
Spatial, 5, 10, 12, 17, 33, 39, 45–47
SpatialGrid, 31
SpatialGridDataFrame, 11, 12, 17
SpatialLinesDataFrame, 17
SpatialPixels, 31
SpatialPixelsDataFrame, 11, 17
SpatialPoints, 31, 40
SpatialPointsDataFrame, 5, 17, 19, 20, 31, 39, 40, 47
SpatialPolygons, 8
SpatialPolygonsDataFrame, 17
spatialPredict, 7, 16, 22, 23, 31–33, 41
spatialPredict.block (blockPredict), 8
spatialPredict.copula, 30
spplot, 36
summary.automap (summaryIntamap), 43
summary.copula (summaryIntamap), 43
summary.idw (summaryIntamap), 43
summary.linearVariogram (summaryIntamap), 43
summary.transGaussian (summaryIntamap), 43
summary.yamamoto (summaryIntamap), 43
summaryIntamap, 43
timeModels, 44
unbiasedKrige, 17, 45
vgm, 34, 45, 47
xyplot, 36
yamamotoKrige, 42, 47