Package: spm2 (via r-universe)

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Title Spatial Predictive Modeling

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Description An updated and extended version of 'spm' package, by introducing some further novel functions for modern statistical methods (i.e., generalised linear models, glmnet, generalised least squares), thin plate splines, support vector machine, kriging methods (i.e., simple kriging, universal kriging, block kriging, kriging with an external drift), and novel hybrid methods (228 hybrids plus numerous variants) of modern statistical methods or machine learning methods with mathematical and/or univariate geostatistical methods for spatial predictive modelling. For each method, two functions are provided, with one function for assessing the predictive errors and accuracy of the method based on cross-validation, and the other for generating spatial predictions. It also contains a couple of functions for data preparation and predictive accuracy assessment.

Depends R (>= 2.10)

Imports spm, gstat, sp, randomForest, gbm, stats, fields, nlme, glmnet, e1071

License GPL (>= 2)

LazyData true

RoxygenNote 7.1.1

Encoding UTF-8

Suggests knitr, rmarkdown

NeedsCompilation no

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Contents

bees *A dataset of bees count data and relevant information in oilseed Brassica fields in an Australian temperate landscape.*

Description

This dataset contains 212 samples of 61 variables including three bee species, inflorescence, temperature, wid speed and various derived landscape variables.

Usage

```
data("bees")
```

Format

A data frame with 212 observations on the following 61 variables.

`transid` a factor with levels `G1` `G10` `G11` `G12` `G13` `G14` `G15` `G16` `G1D1` `G1D10` `G1D11` `G1D12` `G1D13` `G1D14` `G1D15` `G1D16` `G1D17` `G1D2` `G1D3` `G1D4` `G1D5` `G1D6` `G1D7` `G1D8` `G1D9` `G1G1` `G1G10` `G1G11` `G1G12` `G1G13` `G1G14` `G1G15` `G1G16` `G1G17` `G1G2` `G1G3` `G1G4` `G1G5` `G1G6` `G1G7` `G1G8` `G1G9` `G2` `G2H1` `G2H10` `G2H11` `G2H2` `G2H3` `G2H4` `G2H5` `G2H6` `G2H7` `G2H8` `G2H9` `G2S1` `G2S10` `G2S11` `G2S2` `G2S3` `G2S4` `G2S5` `G2S6` `G2S7` `G2S8` `G2S9` `G3` `G4` `G5` `G6` `G7` `G8` `G9` `GCH1` `GCH10` `GCH11` `GCH12` `GCH13` `GCH14` `GCH15` `GCH16` `GCH17` `GCH18` `GCH2` `GCH3` `GCH4` `GCH5` `GCH6` `GCH7` `GCH8` `GCH9` `GCS1` `GCS10` `GCS11` `GCS12` `GCS13` `GCS14` `GCS15` `GCS16` `GCS17` `GCS18` `GCS2` `GCS3` `GCS4` `GCS5` `GCS6` `GCS7` `GCS8` `GCS9` `H1` `H10` `H11` `H12` `H13` `H14` `H15` `H16` `H2` `H3` `H4` `H5` `H6` `H7` `H8` `H9` `MC1G1` `MC1G2` `MC1G3` `MC1G4` `MC1G5` `MC1G6` `MC1G7` `MC1G8` `MC1G9` `MC1H1` `MC1H2` `MC1H3` `MC1H4` `MC1H5` `MC1H6` `MC1H7` `MC1H8` `MC1H9` `MC2AH1` `MC2AH10` `MC2AH11` `MC2AH12` `MC2AH13` `MC2AH14` `MC2AH15` `MC2AH16` `MC2AH17` `MC2AH18` `MC2AH2` `MC2AH3` `MC2AH4` `MC2AH5` `MC2AH6` `MC2AH7` `MC2AH8` `MC2AH9` `MC2AS1` `MC2AS10` `MC2AS11` `MC2AS12` `MC2AS13` `MC2AS14` `MC2AS15` `MC2AS16` `MC2AS17` `MC2AS18` `MC2AS2` `MC2AS3` `MC2AS4` `MC2AS5` `MC2AS6` `MC2AS7` `MC2AS8` `MC2AS9` `MC2BB1` `MC2BB10` `MC2BB11` `MC2BB12` `MC2BB13` `MC2BB14` `MC2BB15` `MC2BB16` `MC2BB17` `MC2BB2` `MC2BB3` `MC2BB4` `MC2BB5` `MC2BB6` `MC2BB7` `MC2BB8` `MC2BB9` `MC2BG1` `MC2BG10` `MC2BG11` `MC2BG12` `MC2BG13` `MC2BG14` `MC2BG15` `MC2BG16` `MC2BG17` `MC2BG2` `MC2BG3` `MC2BG4` `MC2BG5` `MC2BG6` `MC2BG7` `MC2BG8` `MC2BG9`

`transsurv` a numeric vector

`plotsurv` a numeric vector

`paddock` a numeric vector

`plot` a factor with levels `G1-1` `G1-10` `G1-11` `G1-12` `G1-13` `G1-14` `G1-15` `G1-16` `G1-17` `G1-2` `G1-3` `G1-4` `G1-5` `G1-6` `G1-7` `G1-8` `G1-9` `G21` `G210` `G211` `G22` `G23` `G24` `G25` `G26` `G27` `G28` `G29` `GC1` `GC10` `GC11` `GC12` `GC13` `GC14` `GC15` `GC16` `GC17` `GC18` `GC2` `GC3` `GC4` `GC5` `GC6` `GC7` `GC8` `GC9` `MC-1` `MC-10` `MC-11` `MC-12` `MC-13` `MC-14` `MC-15` `MC-16` `MC-2` `MC-3` `MC-4` `MC-5` `MC-6` `MC-7` `MC-8` `MC-9` `MC1-1` `MC1-2` `MC1-3` `MC1-4` `MC1-5` `MC1-6` `MC1-7` `MC1-8` `MC1-9` `MC2-A1` `MC2-A10` `MC2-A11` `MC2-A12` `MC2-A13` `MC2-A14` `MC2-A15` `MC2-A16` `MC2-A17` `MC2-A18` `MC2-A2` `MC2-A3` `MC2-A4` `MC2-A5` `MC2-A6` `MC2-A7` `MC2-A8` `MC2-A9` `MC2-B1` `MC2-B10` `MC2-B11` `MC2-B12` `MC2-B13` `MC2-B14` `MC2-B15` `MC2-B16` `MC2-B17` `MC2-B2` `MC2-B3` `MC2-B4` `MC2-B5` `MC2-B6` `MC2-B7` `MC2-B8` `MC2-B9`

`obs` a factor with levels `Andrew` `Barbara` `Micah` `Sonia` `Steve`

`hbee`	a numeric vector
`nbee`	a numeric vector
`hover`	a numeric vector
`date`	a numeric vector
`sx`	a numeric vector
`fx`	a numeric vector
`sy`	a numeric vector
`fy`	a numeric vector
`loc`	a factor with levels `100` `150` `200` `400` `450` `edge`
`pair`	a factor with levels `I` `O`
`inf`	a numeric vector
`rankinf`	a numeric vector
`dupl`	a numeric vector
`temp`	a numeric vector
`windspeed`	a numeric vector
`winddir`	a factor with levels `N` `NE` `NNE` `NNW` `NW`
`cloudc`	a numeric vector
`disttoedgecalc`	a numeric vector
`disttoedgemeasured`	a numeric vector
`w100`	a numeric vector
`w200`	a numeric vector
`w300`	a numeric vector
`w400`	a numeric vector
`w500`	a numeric vector
`w600`	a numeric vector
`w700`	a numeric vector
`w800`	a numeric vector
`w900`	a numeric vector
`w1000`	a numeric vector
`w1500`	a numeric vector
`w2000`	a numeric vector
`c100`	a numeric vector
`c200`	a numeric vector
`c300`	a numeric vector
`c400`	a numeric vector
`c500`	a numeric vector
`c1000`	a numeric vector

`c1500` a numeric vector

`area` a numeric vector

`perimeter` a numeric vector

`gyration` a numeric vector

`paratio` a numeric vector

`shape` a numeric vector

`fractaldimention` a numeric vector

`circumscircle` a numeric vector

`contiguity` a numeric vector

`links100` a numeric vector

`links200` a numeric vector

`links300` a numeric vector

`links400` a numeric vector

`links500` a numeric vector

`links1000` a numeric vector

`links1500` a numeric vector

`links2000` a numeric vector

`windspeed2` a numeric vector

Details

For details, please see the source. This dataset was published as an appendix of the paper listed in the source. Where the long and lat were reprojected to easting and northing

Source

The data source is [https://doi.org/10.25919/5f17b34638cca] or [https://data.csiro.au/collections/collection/CIcsiro:45533], which provides bees count data and relevant predictive variables along with a brief description of the data. The detailed descriptions of the data are available in: "Arthur, A. D., et al. (2010). "Influence of woody vegetation on pollinator densities in oilseed Brassica fields in an Australian temperate landscape." Basic and Applied Ecology 11: 406-414."

References

Arthur, A. D., Li, J., Henry, S., Cunningham, S.A. (2010). "Influence of woody vegetation on pollinator densities in oilseed Brassica fields in an Australian temperate landscape." Basic and Applied Ecology 11: 406-414.

`ccr` *Correct classification rate for predictive models based on cross - validation*

Description

This function is to calculates correct classification rate (ccr) for categorical data with the observed (obs) data specified as factor. It based on the differences between the predicted values for and the observed values of validation samples for cross-validation. For 0 and 1 data, the observed values need to be specified as factor in order to use this accuracy measure. It is modified from the function 'pred.acc' in 'spm' package.

Usage

```
ccr(obs, pred)
```

Arguments

`obs`	a vector of observation values of validation samples.
`pred`	a vector of prediction values of predictive models for validation samples.

Value

A list with the following component: ccr (correct classification rate) for categorical data.

Author(s)

Jin Li

References

Jin Li (2019). spm: Spatial Predictive Modeling. R package version 1.2.0. https://CRAN.R-project.org/package=spm.

Examples

```
set.seed(1234)
x <- as.factor(sample(letters[1:2], 30, TRUE))
y <- sample(x, 30)
ccr(x, y)
```

`cran-comments` *Note on notes*

Description

This is an updated and extended version of ‘spm‘ package. The change in package name from ‘spm‘ to ‘spm2‘ is due to the change in Author’s support from Geoscience Australia to Data2Action Australia.

## R CMD check results 0 errors | 0 warnings | 0 notes

Author(s)

Jin Li

`datasplit` *Split data for k-fold cross-validation*

Description

This function is a data splitting function for k-fold cross- validation and uses a stratified random sampling technique. It resamples the training data based on sample quantiles.

Usage

```
datasplit(trainy, k.fold = 10)
```

Arguments

`trainy`	a vector of response, must have a length equal to sample size.
`k.fold`	integer; number of folds in the cross-validation. if > 1, then apply k-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.

Value

A list of samples each with an index of k-fold number.

Note

This function is largely based on rfcv in randomForest.

Author(s)

Jin Li

References

A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18-22.

Examples

```
library(spm)
data(petrel)
idx1 <- datasplit(petrel[, 3], k.fold = 10)
table(idx1)
```

---

decimaldigit *Digit number after decimal point for a numeric variable*

Description

This function is to derive the digit number after decimal point for a numeric variable (e.g., lat and long).

Usage

```
decimaldigit(x, dechar = ".", nint = NA, ndec = NA, pad.left = TRUE)
```

Arguments

`x`	one or more decimal numbers.
`dechar`	The character used to separate the decimal part of a number.
`nint`	The number of characters to which the integer part of the numbers should be padded.
`ndec`	The number of characters to which the decimal part of the numbers should be padded.
`pad.left`	Whether the left (integer) side of the numbers should be padded as well as the right.

Value

A list of integer number to show digit number after decimal point of x.

Note

This function is modified from decimal.align in 'prettyR' package.

Author(s)

Jin Li

References

Jim Lemon and Philippe Grosjean (2019). 'prettyR': Pretty Descriptive Stats. R package version 2.1.1. https://CRAN.R-project.org/package=prettyR.

Examples

```
x<-c(0.1, 2.2, 3.03, 44.444, 555.0005, 6666.66666)
decimaldigit(x)
```

`gbmkrigeidwcv` *Cross validation, n-fold and leave-one-out for the hybrid methods of generalized boosted regression modeling ('gbm'), 'kriging' and inverse distance weighted ('IDW').*

Description

This function is a cross validation function for 38 hybrid methods of 'gbm', 'kriging' and 'IDW', including the average of 'gbmkrige' and 'gbmidw' ('gbmkrigegbmidw') and the average of 'gbm', 'gbmkrige' and 'gbmidw' ('gbmgbmkrigegbmidw'), where 'kriging' methods include ordinary kriging ('OK'), simple kriging ('SK'), block 'OK' ('BOK') and block 'SK'('BSK') and 'IDW' also covers 'NN' and 'KNN'. The data splitting is based on a stratified random sampling method (see the 'datasplit' function for details).

Usage

```
gbmkrigeidwcv(
  longlat,
  trainx,
  trainy,
  var.monotone = rep(0, ncol(trainx)),
  family = "gaussian",
  n.trees = 3000,
  learning.rate = 0.001,
  interaction.depth = 2,
  bag.fraction = 0.5,
  train.fraction = 1,
  n.minobsinnode = 10,
  transformation = "none",
  weights = rep(1, nrow(trainx)),
  keep.data = FALSE,
  verbose = TRUE,
  delta = 1,
  formula = res1 ~ 1,
  vgm.args = "Sph",
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  n.cores = 6,
  ...
)
```

Arguments

`longlat`	a dataframe contains longitude and latitude of point samples.
`trainx`	a dataframe or matrix contains columns of predictive variables.
`trainy`	a vector of the response variable.
`var.monotone`	an optional vector, the same length as the number of predictors, indicating which variables have a monotone increasing (+1), decreasing (-1), or arbitrary (0) relationship with the outcome. By default, a vector of 0 is used.
`family`	either a character string specifying the name of the distribution to use or a list with a component name specifying the distribution and any additional parameters needed. See gbm for details. By default, "gaussian" is used.
`n.trees`	the total number of trees to fit. This is equivalent to the number of iterations and the number of basis functions in the additive expansion. By default, 3000 is used.
`learning.rate`	a shrinkage parameter applied to each tree in the expansion. Also known as step-size reduction.
`interaction.depth`	the maximum depth of variable interactions. 1 implies an additive model, 2 implies a model with up to 2-way interactions, etc. By default, 2 is used.
`bag.fraction`	the fraction of the training set observations randomly selected to propose the next tree in the expansion. By default, 0.5 is used.
`train.fraction`	The first train.fraction * nrows(data) observations are used to fit the gbm and the remainder are used for computing out-of-sample estimates of the loss function.
`n.minobsinnode`	minimum number of observations in the trees terminal nodes. Note that this is the actual number of observations not the total weight. By default, 10 is used.
`transformation`	transform the residuals of 'gbm' to normalize the data for 'krige'; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`weights`	an optional vector of weights to be used in the fitting process. Must be positive but do not need to be normalized. If keep.data = FALSE in the initial call to gbm then it is the user's responsibility to resupply the weights to gbm.more. By default, a vector of 1 is used.

`keep.data`	a logical variable indicating whether to keep the data and an index of the data stored with the object. Keeping the data and index makes subsequent calls to gbm.more faster at the cost of storing an extra copy of the dataset. By default, 'FALSE' is used.
`verbose`	If TRUE, gbm will print out progress and performance indicators. By default, 'TRUE' is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details. The default is 'formula = res1 ~ 1'.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`hybrid.parameter`	the default is 2 that is for 'gbmkrigegbmidw'; for 'gbmgbmkrigegbmidw', it needs to be 3.
`lambda`	ranging from 0 to 2; the default is 1 for 'gbmkrigegbmidw' and 'gbmgbmkrigegbmidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'gbmkrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'gbmidw' when the default 'hybrid.parameter' is used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`n.cores`	The number of CPU cores to use. See gbm for details. By default, 6 is used.
`...`	other arguments passed on to 'randomForest', 'krige' and 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'gbmcv' in 'spm', and 'krigecv' in 'spm2'.

Author(s)

Jin Li

References

Li, J. (2022). Spatial Predictive Modeling with R. Boca Raton, Chapman and Hall/CRC.

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

Greg Ridgeway with contributions from others (2015). gbm: Generalized Boosted Regression Models. R package version 2.1.1. https://CRAN.R-project.org/package=gbm

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
# gbmgbmokgbmidw
data(sponge)
longlat <- sponge[, 1:2]
set.seed(1234)
gbmgbmkrigegbmidwcv1 <- gbmkrigeidwcv(longlat = longlat,
trainx = sponge[, -3], trainy = sponge[, 3], family = "poisson", interaction.depth = 3,
transformation = "none", formula = res1 ~ 1, vgm.args = "Sph",
nmaxkrige = 12, idp = 2, nmaxidw = 12, hybrid.parameter = 3, validation = "CV",
predacc = "ALL", n.cores = 2)
gbmgbmkrigegbmidwcv1

# gbmokgbmidw for count data
data(sponge)
longlat <- sponge2[, 1:2]
y = sponge[, 3]
trainx = sponge[, -3]
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
  gbmkrigegbmidwcv1 <- gbmkrigeidwcv(longlat = longlat,
  trainx = trainx, trainy = y, family = "poisson", interaction.depth = 3,
  transformation = "none", formula = res1 ~ 1, vgm.args = ("Sph"),
  nmaxkrige = 12, idp = 2, nmaxidw = 12, hybrid.parameter = 2, validation = "CV",
  predacc = "VEcv", n.cores = 2)
  VEcv [i] <- gbmkrigegbmidwcv1
 }
 plot(VEcv ~ c(1:n), xlab = "Iteration for gbmokgbmidw", ylab = "VEcv (%)")
 points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
 abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

gbmkrigeidwpred *Generate spatial predictions using the hybrid methods of generalized boosted regression modeling ('gbm'), 'kriging' and inverse distance weighted ('IDW').*

Description

This function is for generating spatial predictions using the hybrid methods of 'gbm', 'kriging' and 'IDW', including all methods implemented in 'gbmkrigeidwcv'.

Usage

```
gbmkrigeidwpred(
  longlat,
  trainx,
  predx,
  trainy,
  longlatpredx,
  var.monotone = rep(0, ncol(trainx)),
  family = "gaussian",
  n.trees = 3000,
  learning.rate = 0.001,
  interaction.depth = 2,
  bag.fraction = 0.5,
  train.fraction = 1,
  n.minobsinnode = 10,
  transformation = "none",
  weights = rep(1, nrow(trainx)),
  keep.data = FALSE,
  verbose = TRUE,
  delta = 1,
  formula = res1 ~ 1,
  vgm.args = "Sph",
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  cv.fold = 10,
  n.cores = 8,
  ...
)
```

Arguments

`longlat`	a dataframe contains longitude and latitude of point samples.
`trainx`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`trainy`	a vector of the response variable in the formula, that is, the left part of the formula.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted.
`var.monotone`	an optional vector, the same length as the number of predictors, indicating which variables have a monotone increasing (+1), decreasing (-1), or arbitrary (0) relationship with the outcome. By default, a vector of 0 is used.
`family`	either a character string specifying the name of the distribution to use or a list with a component name specifying the distribution and any additional parameters needed. See gbm for details. By default, "gaussian" is used.
`n.trees`	the total number of trees to fit. This is equivalent to the number of iterations and the number of basis functions in the additive expansion. By default, 3000 is used.
`learning.rate`	a shrinkage parameter applied to each tree in the expansion. Also known as step-size reduction.
`interaction.depth`	the maximum depth of variable interactions. 1 implies an additive model, 2 implies a model with up to 2-way interactions, etc. By default, 2 is used.
`bag.fraction`	the fraction of the training set observations randomly selected to propose the next tree in the expansion. By default, 0.5 is used.
`train.fraction`	The first 'train.fraction * nrows(data)' observations are used to fit the gbm and the remainder are used for computing out-of-sample estimates of the loss function.
`n.minobsinnode`	minimum number of observations in the trees terminal nodes. Note that this is the actual number of observations not the total weight. By default, 10 is used.
`transformation`	transform the residuals of 'gbm' to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.

`weights`	an optional vector of weights to be used in the fitting process. Must be positive but do not need to be normalized. If keep.data = FALSE in the initial call to gbm then it is the user's responsibility to resupply the weights to gbm.more. By default, a vector of 1 is used.
`keep.data`	a logical variable indicating whether to keep the data and an index of the data stored with the object. Keeping the data and index makes subsequent calls to gbm.more faster at the cost of storing an extra copy of the dataset. By default, 'FALSE' is used.
`verbose`	If TRUE, gbm will print out progress and performance indicators. By default, 'TRUE' is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details. The default is 'formula = res1 ~ 1'.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`hybrid.parameter`	the default is 2 that is for 'gbmkrigegbmidw'; for 'gbmgbmkrigegbmidw', it needs to be 3.
`lambda`	ranging from 0 to 2; the default is 1 for 'gbmkrigegbmidw' and 'gbmgbmkrigegbmidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'gbmkrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'gbmidw' when the default 'hybrid.parameter' is used.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`n.cores`	The number of CPU cores to use. See gbm for details. By default, 6 is used.
`...`	other arguments passed on to 'gbm', 'krige' and 'gstat'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

Greg Ridgeway with contributions from others (2015). gbm: Generalized Boosted Regression Models. R package version 2.1.1. https://CRAN.R-project.org/package=gbm

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(sponge)
data(sponge.grid)
longlat <- sponge[, 1:2]

set.seed(1234)

gbmkrigeidwpred1 <- gbmkrigeidwpred(longlat = longlat, trainx = sponge[, -3],
predx = sponge.grid, trainy = sponge[, 3], longlatpredx = sponge.grid[, c(1:2)],
family = "poisson", interaction.depth = 3, transformation = "none", formula = res1 ~ 1,
vgm.args = "Sph", nmaxkrige = 12, idp = 2, nmaxidw = 12, hybrid.parameter = 3,
n.cores = 2)

names(gbmkrigeidwpred1)

range(gbmkrigeidwpred1$predictions)
```

---

glmcv — *Cross validation, n-fold and leave-one-out for generalised linear models ('glm')*

Description

This function is a cross validation function for 'glm' method in 'stats' package.

Usage

```
glmcv(
  formula = NULL,
  trainxy,
  y,
  family = "gaussian",
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`formula`	a formula defining the response variable and predictive variables.
`trainxy`	a dataframe contains predictive variables and the response variable of point samples. The location information, longitude (long), latitude (lat), need to be included in the 'trainx' for spatial predictive modeling.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`family`	a description of the error distribution and link function to be used in the model. See '?glm' for details.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'glm'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'rfcv' in 'randomForest' and 'glm' in 'stats'.

Author(s)

Jin Li

References

A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18-22.

Examples

```
library(spm)

data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
set.seed(1234)
glmcv1 <- glmcv(formula = model, gravel, log(gravel[, 7] +1), validation = "CV",
 predacc = "ALL")
glmcv1 # Since the default 'family' is used, it is actually a 'lm' model.

data(sponge)
model <- sponge ~ easting + I(easting^2)
set.seed(1234)
glmcv1 <- glmcv(formula = model, sponge, sponge[, 3], family = poisson,
validation = "CV",  predacc = "ALL")
glmcv1

# For glm
model <- gravel / 100 ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glmcv1 <- glmcv(formula = model, gravel, gravel[, 7] / 100, family =
binomial(link=logit), validation = "CV", predacc = "VEcv")
VEcv [i] <- glmcv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLM", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

---

glmidwcv

Cross validation, n-fold and leave-one-out for the hybrid method of generalised linear models ('glm') and inverse distance weighted ('IDW') ('glmidw')

Description

This function is a cross validation function for the hybrid method of 'glm' and 'idw' using 'gstat' (glmidw) (see reference #1), where the data splitting is based on a stratified random sampling method (see the 'datasplit' function for details).

Usage

```
glmidwcv(
  formula = NULL,
  longlat,
  trainxy,
  y,
  family = "gaussian",
  idp = 2,
  nmaxidw = 12,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`formula`	a formula defining the response variable and predictive variables for 'glm'.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`family`	a description of the error distribution and link function to be used in the model. See '?glm' for details.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'glm' and 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only.

Note

This function is largely based on 'rfcv' in 'randomForest', 'idwcv' in 'spm'and 'glm' in 'stats'.

Author(s)

Jin Li

References

Li, J., Alvarez, B., Siwabessy, J., Tran, M., Huang, Z., Przeslawski, R., Radke, L., Howard, F. and Nichol, S. (2017). "Application of random forest, generalised linear model and their hybrid methods with geostatistical techniques to count data: Predicting sponge species richness." Environmental Modelling & Software 97: 112-129.

A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18-22.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)

set.seed(1234)
glmidwcv1 <- glmidwcv(formula = model, longlat = longlat, trainxy =  gravel,
y = y, idp = 2, nmaxidw = 12, validation = "CV", predacc = "ALL")
glmidwcv1 # Since the default 'family' is used, actually a 'lm' model is used.

data(spongelonglat)
longlat <- spongelonglat[, 7:8]
model <- sponge ~ long + I(long^2)
y = spongelonglat[, 1]
set.seed(1234)
glmidwcv1 <- glmidwcv(formula = model, longlat = longlat, trainxy = spongelonglat,
y = y, family = poisson, idp = 2, nmaxidw = 12, validation = "CV",
predacc = "ALL")
glmidwcv1

# glmidw for count data
data(spongelonglat)
longlat <- spongelonglat[, 7:8]
model <- sponge ~ . # use all predictive variables in the dataset
y = spongelonglat[, 1]
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
 glmidwcv1 <- glmidwcv(formula = model, longlat = longlat, trainxy = spongelonglat,
 y = y, family = poisson, idp = 2, nmaxidw = 12, validation = "CV",
 predacc = "VEcv")
 VEcv [i] <- glmidwcv1
 }
 plot(VEcv ~ c(1:n), xlab = "Iteration for GLM", ylab = "VEcv (%)")
 points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
 abline(h = mean(VEcv), col = 'blue', lwd = 2)

# glmidw for percentage data
longlat <- petrel[, c(1, 2)]
model <- gravel / 100 ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glmidwcv1 <- glmcv(formula = model, longlat = longlat, trainxy = gravel,
y = gravel[, 7] / 100, family = binomial(link=logit), idp = 2, nmaxidw = 12,
validation = "CV", predacc = "VEcv")
VEcv [i] <- glmidwcv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLM", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

glmidwpred

Generate spatial predictions using the hybrid method of generalised linear models ('glm') and inverse distance weighted ('IDW') ('glmidw')

Description

This function is for generating spatial predictions using the hybrid method of 'glm' and 'idw' ('glmidw') (see reference #1).

Usage

```
glmidwpred(
  formula = NULL,
  longlat,
  trainxy,
  y,
  longlatpredx,
  predx,
  family = "gaussian",
  idp = 2,
  nmaxidw = 12,
  ...
)
```

Arguments

`formula`	a formula defining the response variable and predictive variables for 'glm'.

`longlat`	a dataframe contains longitude and latitude of point samples. The location information must be named as 'long' and 'lat'.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be named as 'long' and 'lat'.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`family`	a description of the error distribution and link function to be used in the model. See '?glm' for details.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`...`	other arguments passed on to 'glm'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Li, J., Alvarez, B., Siwabessy, J., Tran, M., Huang, Z., Przeslawski, R., Radke, L., Howard, F. and Nichol, S. (2017). "Application of random forest, generalised linear model and their hybrid methods with geostatistical techniques to count data: Predicting sponge species richness." Environmental Modelling & Software 97: 112-129.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)
```

```
glmidwpred1 <- glmidwpred(formula = model, longlat = longlat, trainxy =  gravel,
y = y, longlatpredx = petrel.grid[, c(1:2)], predx = petrel.grid, idp = 2,
 nmaxidw = 12)
 # Since the default 'family' is used, actually a 'lm' model is used.

names(glmidwpred1)

# Back transform 'glmidwpred$predictions' to generate the final predictions
glmidwpred1$predictions.bt <- exp(glmidwpred1$predictions) - 1
range(glmidwpred1$predictions.bt)
```

---

glmkrigecv — *Cross validation, n-fold and leave-one-out for the hybrid method of generalised linear models ('glm') and 'krige' ('glmkrige')*

Description

This function is a cross validation function for the hybrid method of 'glm' and 'krige' (glmkrige), where 'krige' methods include ordinary kriging ('OK'), simple kriging ('SK'), block 'OK' ('BOK') and block 'SK'('BSK') (see reference #1 for further info).

Usage

```
glmkrigecv(
  formula.glm = NULL,
  longlat,
  trainxy,
  y,
  family = "gaussian",
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`formula.glm`	a formula defining the response variable and predictive variables for 'glm'.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`family`	a description of the error distribution and link function to be used in the model. See '?glm' for details.
`transformation`	transform the residuals of 'glm' to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'glm' and 'krige'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'rfcv' in 'randomForest', 'krigecv' in 'spm2'and 'glm' in 'stats'.

Author(s)

Jin Li

References

Li, J., Alvarez, B., Siwabessy, J., Tran, M., Huang, Z., Przeslawski, R., Radke, L., Howard, F. and Nichol, S. (2017). "Application of random forest, generalised linear model and their hybrid methods with geostatistical techniques to count data: Predicting sponge species richness." Environmental Modelling & Software 97: 112-129.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(petrel)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)
set.seed(1234)
glmkrigecv1 <- glmkrigecv(formula.glm = model, longlat = longlat, trainxy =  gravel,
y = y, transformation = "none", formula.krige = res1 ~ 1, vgm.args = "Sph",
nmaxkrige = 12, validation = "CV", predacc = "ALL")
glmkrigecv1 # Since the default 'family' is used, actually a 'lm' model is used.

data(spongelonglat)
longlat <- spongelonglat[, 7:8]
model <- sponge ~ long + I(long^2)
y = spongelonglat[, 1]
set.seed(1234)
glmkrigecv1 <- glmkrigecv(formula.glm = model, longlat = longlat, trainxy =
spongelonglat, y = y, family = poisson, transformation = "arcsine",
formula.krige = res1 ~ 1, vgm.args = ("Sph"), nmaxkrige = 12,
validation = "CV", predacc = "ALL")
glmkrigecv1

# glmok for count data
data(spongelonglat)
longlat <- spongelonglat[, 7:8]
model <- sponge ~ . # use all predictive variables in the dataset
y = spongelonglat[, 1]
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
 glmkrigecv1 <- glmkrigecv(formula.glm = model, longlat = longlat, trainxy = spongelonglat,
 y = y, family = poisson, formula.krige = res1 ~ 1, vgm.args = ("Sph"), nmaxkrige = 12,
 validation = "CV",  predacc = "VEcv")
 VEcv [i] <- glmkrigecv1
 }
 plot(VEcv ~ c(1:n), xlab = "Iteration for GLM", ylab = "VEcv (%)")
 points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
 abline(h = mean(VEcv), col = 'blue', lwd = 2)

# glmok for percentage data
longlat <- petrel[, c(1, 2)]
model <- gravel / 100 ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glmkrigecv1 <- glmkrigecv(formula.glm = model, longlat = longlat, trainxy = gravel,
y = gravel[, 7] / 100, family = binomial(link=logit), formula.krige = res1 ~ 1,
vgm.args = ("Sph"), nmaxkrige = 12, validation = "CV", predacc = "VEcv")
VEcv [i] <- glmkrigecv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLM", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

---

glmkrigeidwcv

Cross validation, n-fold and leave-one-out for the hybrid methods of generalised linear models ('glm'), 'kriging' and inverse distance weighted ('IDW').

Description

This function is a cross validation function for 38 hybrid methods of 'glm', 'kriging' and 'IDW', including the average of 'glmkrige' and 'glmidw' ('glmkrigeglmidw') and the average of 'glm', 'glmkrige' and 'glmidw' ('glmglmkrigeglmidw'), where 'kriging' methods include ordinary kriging ('OK'), simple kriging ('SK'), block 'OK' ('BOK') and block 'SK'('BSK') and 'IDW' also covers 'NN' and 'KNN' (for details, see reference #1). This function can also be sued for 38 hybrid methods of 'lm', 'kriging' and 'IDW'.

Usage

```
glmkrigeidwcv(
  formula.glm = NULL,
  longlat,
  trainxy,
  y,
  family = "gaussian",
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`formula.glm`	a formula defining the response variable and predictive variables for 'glm'.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`family`	a description of the error distribution and link function to be used in the model. See '?glm' for details.
`transformation`	transform the residuals of 'glm' to normalise the data for 'krige'; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.

`hybrid.parameter`	the default is 2 that is for 'glmkrigeglmidw'; for 'glmglmkrigeglmidw', it needs to be 3.
`lambda`	ranging from 0 to 2; the default is 1 for 'glmkrigeglmidw' and 'glmglmkrigeglmidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'glmkrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'glmidw' when the default 'hybrid.parameter' is used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'glm', 'krige' and 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'rfcv' in 'randomForest', 'krigecv' in 'spm2'and 'glm' in 'stats'.

Author(s)

Jin Li

References

Li, J. (2022). Spatial Predictive Modeling with R. Boca Raton, Chapman and Hall/CRC.

Li, J., Alvarez, B., Siwabessy, J., Tran, M., Huang, Z., Przeslawski, R., Radke, L., Howard, F. and Nichol, S. (2017). "Application of random forest, generalised linear model and their hybrid methods with geostatistical techniques to count data: Predicting sponge species richness." Environmental Modelling & Software 97: 112-129.

A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18-22.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
# glmokglidw
data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)
```

```
set.seed(1234)
glmkrigeglmidwcv1 <- glmkrigeidwcv(formula.glm = model, longlat = longlat,
trainxy =  gravel, y = y, transformation = "none", formula.krige = res1 ~ 1,
vgm.args = "Sph", nmaxkrige = 12, idp = 2, nmaxidw = 12, validation = "CV",
 predacc = "ALL")
glmkrigeglmidwcv1 # Since the default 'family' is used, actually a 'lm' model is used.

# glmokglmidw
data(spongelonglat)
longlat <- spongelonglat[, 7:8]
model <- sponge ~ long + I(long^2)
y = spongelonglat[, 1]
set.seed(1234)
glmkrigeglmidwcv1 <- glmkrigeidwcv(formula.glm = model, longlat = longlat,
trainxy = spongelonglat, y = y, family = poisson, transformation = "arcsine",
formula.krige = res1 ~ 1, vgm.args = ("Sph"), nmaxkrige = 12, idp = 2,
nmaxidw = 12, validation = "CV", predacc = "ALL")
glmkrigeglmidwcv1

# glmglmokglmidw
data(spongelonglat)
longlat <- spongelonglat[, 7:8]
model <- sponge ~ long + I(long^2)
y = spongelonglat[, 1]
set.seed(1234)
glmglmkrigeglmidwcv1 <- glmkrigeidwcv(formula.glm = model, longlat = longlat,
trainxy = spongelonglat, y = y, family = poisson, transformation = "arcsine",
formula.krige = res1 ~ 1, vgm.args = ("Sph"), nmaxkrige = 12, idp = 2,
nmaxidw = 12, hybrid.parameter = 3, validation = "CV", predacc = "ALL")
glmglmkrigeglmidwcv1

# glmokglidw for count data
data(spongelonglat)
longlat <- spongelonglat[, 7:8]
model <- sponge ~ . # use all predictive variables in the dataset
y = spongelonglat[, 1]
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
 glmkrigeglmidwcv1 <- glmkrigeidwcv(formula.glm = model, longlat = longlat,
 trainxy = spongelonglat, y = y, family = poisson, formula.krige = res1 ~ 1,
 vgm.args = ("Sph"), nmaxkrige = 12, idp = 2, nmaxidw = 12, validation = "CV",
 predacc = "VEcv")
 VEcv [i] <- glmkrigeglmidwcv1
 }
 plot(VEcv ~ c(1:n), xlab = "Iteration for GLM", ylab = "VEcv (%)")
 points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
 abline(h = mean(VEcv), col = 'blue', lwd = 2)

# glmokglmidw for percentage data
longlat <- petrel[, c(1, 2)]
model <- gravel / 100 ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
```

```
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glmkrigeglmidwcv1 <- glmkrigeidwcv(formula.glm = model, longlat = longlat,
trainxy = gravel, y = gravel[, 7] / 100, family = binomial(link=logit),
formula.krige = res1 ~ 1, vgm.args = ("Sph"), nmaxkrige = 12, idp = 2,
nmaxidw = 12, validation = "CV", predacc = "VEcv")
VEcv [i] <- glmkrigeglmidwcv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLM", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

glmkrigeidwpred

Generate spatial predictions using the hybrid methods of generalised linear models ('glm'), 'kriging' and inverse distance weighted ('IDW').

Description

This function is for generating spatial predictions using the hybrid methods of 'glm', 'kriging' and 'IDW', including all methods implemented in 'glmkrigeidwcv'.

Usage

```
glmkrigeidwpred(
  formula.glm = NULL,
  longlat,
  trainxy,
  predx,
  y,
  longlatpredx,
  family = "gaussian",
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  ...
)
```

Arguments

formula.glm	a formula defining the response variable and predictive variables for 'glm'.
longlat	a dataframe contains longitude and latitude of point samples.
trainxy	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples.
predx	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
y	a vector of the response variable in the formula, that is, the left part of the formula.
longlatpredx	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted.
family	a description of the error distribution and link function to be used in the model. See '?glm' for details.
transformation	transform the residuals of 'glm' to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
delta	numeric; to avoid log(0) in the log transformation. The default is 1.
formula.krige	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
vgm.args	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
anis	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
alpha	direction in plane (x,y). see variogram in 'gstat' for details.
block	block size. see 'krige' in 'gstat' for details.
beta	for simple kriging. see 'krige' in 'gstat' for details.
nmaxkrige	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
idp	a numeric number specifying the inverse distance weighting power.
nmaxidw	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
hybrid.parameter	the default is 2 that is for 'glmkrigeglmidw'; for 'glmglmkrigeglmidw', it needs to be 3.

`lambda`	ranging from 0 to 2; the default is 1 for 'glmkrigeglmidw' and 'glmglmkrigeglmidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'glmkrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'glmidw' when the default 'hybrid.parameter' is used.
`...`	other arguments passed on to 'glm', 'krige' and 'gstat'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Li, J., Alvarez, B., Siwabessy, J., Tran, M., Huang, Z., Przeslawski, R., Radke, L., Howard, F. and Nichol, S. (2017). "Application of random forest, generalised linear model and their hybrid methods with geostatistical techniques to count data: Predicting sponge species richness." Environmental Modelling & Software 97: 112-129.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)

glmkrigeidwpred1 <- glmkrigeidwpred(formula.glm = model, longlat = longlat, trainxy = gravel,
predx = petrel.grid, y = y, longlatpredx = petrel.grid[, c(1:2)],
formula.krige = res1 ~ 1, vgm.args = "Sph", nmaxkrige = 12, idp = 2, nmaxidw = 12)
 # Since the default 'family' is used, actually a 'lm' model is used.

names(glmkrigeidwpred1)

# Back transform 'glmkrigeidwpred$predictions' to generate the final predictions
glmkrigeidw.predictions <- exp(glmkrigeidwpred1$predictions) - 1
range(glmkrigeidw.predictions)
```

glmkrigepred — *Generate spatial predictions using the hybrid method of generalised linear models ('glm') and 'krige'*

Description

This function is for generating spatial predictions using the hybrid method of 'glm' and 'krige', including all methods implemented in 'glmkrigecv'. (see reference #1 for further info).

Usage

```
glmkrigepred(
  formula.glm = NULL,
  longlat,
  trainxy,
  predx,
  y,
  longlatpredx,
  family = "gaussian",
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  ...
)
```

Arguments

`formula.glm`	a formula defining the response variable and predictive variables for 'glm'.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted.
`family`	a description of the error distribution and link function to be used in the model. See '?glm' for details.

`transformation`	transform the residuals of 'glm' to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`...`	other arguments passed on to 'glm' and 'krige'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Li, J., Alvarez, B., Siwabessy, J., Tran, M., Huang, Z., Przeslawski, R., Radke, L., Howard, F. and Nichol, S. (2017). "Application of random forest, generalised linear model and their hybrid methods with geostatistical techniques to count data: Predicting sponge species richness." Environmental Modelling & Software 97: 112-129.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)
```

```
glmkrigepred1 <- glmkrigepred(formula.glm = model, longlat = longlat, trainxy =  gravel,
predx = petrel.grid, y = y, longlatpredx = petrel.grid[, c(1:2)],
transformation = "none", formula.krige = res1 ~ 1, vgm.args = "Sph", nmaxkrige = 12)
 # Since the default 'family' is used, actually a 'lm' model is used.

names(glmkrigepred1)

# Back transform 'glmkrigepred$predictions' to generate the final predictions
glmkrige.predictions <- exp(glmkrigepred1$predictions) - 1
range(glmkrige.predictions)
```

---

glmnetcv — *Cross validation, n-fold and leave-one-out, for 'glmnet' in 'glmnet' package*

Description

This function is a cross validation function for 'glmnet' method in 'glmnet' package.

Usage

```
glmnetcv(
  trainx,
  y,
  family = "gaussian",
  alpha = 0.5,
  relax = FALSE,
  type.measure = "mse",
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`trainx`	a matrix contains predictive variables of point samples. The location information, longitude (long), latitude (lat), need to be included in the 'trainx' for spatial predictive modelling.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`family`	a description of the error distribution and link function to be used in the model. See '?glmnet' for details.
`alpha`	an elasticnet mixing parameter, with $0 <= alpha <= 1$. See '?glmnet' for details.

`relax`	if TRUE then for each active set in the path of solutions, the model is refit without any regularization. See '?glmnet' for more information.
`type.measure`	loss to use for cross-validation. The default is type.measure="mse". See '?cv.glmnet' for more information.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'fields'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'glmcv' in this 'spm2' package.

Author(s)

Jin Li

References

A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18-22.

Examples

```
library(spm)

data(petrel)
x <- as.matrix(petrel[, c(1, 2, 6:9)])
y <- log(petrel[, 5] + 1)
set.seed(1234)
glmnetcv1 <- glmnetcv(x, y, validation = "CV",  predacc = "ALL")
glmnetcv1

data(sponge)
x <- as.matrix(cbind(sponge$easting, sponge$easting^2))
set.seed(1234)
glmnetcv1 <- glmnetcv(x, sponge[, 3], family = poisson, validation = "CV",
predacc = "ALL")
glmnetcv1

# For glmnet with gaussian
x <- as.matrix(petrel[, c(1, 2, 6:9)])
y <- log(petrel[, 5] + 1)
set.seed(1234)
```

```
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
  glmnetcv1 <- glmnetcv(x, y, validation = "CV", predacc = "VEcv")
  VEcv [i] <- glmnetcv1
 }
plot(VEcv ~ c(1:n), xlab = "Iteration for glmnet", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)

# For glmnet with binomial
x <- as.matrix(cbind(petrel[, c(2, 6)], petrel$long^3, petrel$lat^2, petrel$lat^3))
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glmnetcv1 <- glmnetcv(x, petrel[, 5] / 100, family = binomial(link=logit),
validation = "CV", predacc = "VEcv")
VEcv [i] <- glmnetcv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for glmnet", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

`glmpred` *Generate spatial predictions using generalised linear models ('glm')*

Description

This function is for generating spatial predictions using 'glm' method in 'stats' package.

Usage

```
glmpred(formula = NULL, trainxy, longlatpredx, predx, family = "gaussian", ...)
```

Arguments

`formula`	a formula defining the response variable and predictive variables.
`trainxy`	a dataframe contains predictive variables and the response variable of point samples. The location information, longitude (long), latitude (lat), need to be included in the 'trainx' for spatial predictive modeling, need to be named as 'long' and 'lat'.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.

`family`	a description of the error distribution and link function to be used in the model. See '?glm' for details.
`...`	other arguments passed on to 'glm'.

Value

A dataframe of longitude, latitude and predictions.

Author(s)

Jin Li

Examples

```
library(spm)
data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)

glmpred1 <- glmpred(formula = model, trainxy = gravel,
longlatpredx = petrel.grid[, c(1:2)], predx = petrel.grid)

names(glmpred1)

# Back transform 'glmpred1$pred.glm1' to generate the final predictions
glm.predictions <- exp(glmpred1$pred.glm1) - 1
range(glm.predictions)
```

---

glscv — *Cross validation, n-fold and leave-one-out for generalized least squares ('gls')*

Description

This function is a cross validation function for 'gls' method in 'nlme' package.

Usage

```
glscv(
  model = var1 ~ 1,
  trainxy,
  y,
  corr.args = NULL,
  weights = NULL,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`model`	a formula defining the response variable and predictive variables.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be names as 'long' and 'lat'.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`corr.args`	arguments for 'correlation' in 'gls'. See '?corClasses' in 'nlme' for details. By default, "NULL" is used. When "NULL" is used, then 'gls' is actually performing 'lm'.
`weights`	describing the within-group heteroscedasticity structure. Defaults to "NULL", corresponding to homoscedastic errors. See '?gls' in 'nlme' for details.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'gls'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on rfcv in 'randomForest' and 'gls' in 'library(nlme)'.

Author(s)

Jin Li

References

Pinheiro, J. C. and D. M. Bates (2000). Mixed-Effects Models in S and S-PLUS. New York, Springer.

Examples

```
library(spm)
library(nlme)

data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
range1 <- 0.8
nugget1 <- 0.5

model <- log(gravel + 1) ~  long + lat +  bathy + dist + I(long^2) + I(lat^2) +
I(lat^3) + I(bathy^2) + I(bathy^3) + I(dist^2) + I(dist^3) + I(relief^2) + I(relief^3)


glscv1 <- glscv(model = model, gravel, log(gravel[, 7] +1), validation = "CV",
 corr.args = corSpher(c(range1, nugget1), form = ~ long + lat, nugget = TRUE),
 predacc = "ALL")
glscv1

#For gls
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glscv1 <- glscv(model = model, gravel, log(gravel[, 7] +1), validation = "CV",
          corr.args = corSpher(c(range1, nugget1), form = ~ long + lat,
          nugget = TRUE), predacc = "VEcv")
VEcv [i] <- glscv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLS", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)

# For lm, that is, gls with 'correlation = NULL'
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
set.seed(1234)
for (i in 1:n) {
glscv1 <- glscv(model = model, gravel, log(gravel[, 7] +1),
validation = "CV", predacc = "VEcv")
VEcv [i] <- glscv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLS", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

---

glsidwcv — *Cross validation, n-fold and leave-one-out for the hybrid method of generalized least squares ('gls') and inverse distance weighted ('idw') (glsidw)*

Description

This function is a cross validation function for the hybrid method of 'gls' and 'idw', where the data splitting is based on a stratified random sampling method (see the 'datasplit' function for details)

Usage

```
glsidwcv(
  model = var1 ~ 1,
  longlat,
  trainxy,
  y,
  corr.args = NULL,
  weights = NULL,
  idp = 2,
  nmaxidw = 12,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`model`	a formula defining the response variable and predictive variables.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be names as 'long' and 'lat'.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`corr.args`	arguments for 'correlation' in 'gls'. See '?corClasses' in 'nlme' for details. By default, "NULL" is used. When "NULL" is used, then 'gls' is actually performing 'lm'.
`weights`	describing the within-group heteroscedasticity structure. Defaults to "NULL", corresponding to homoscedastic errors. See '?gls' in 'nlme' for details.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'gls' and 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only.

Note

This function is largely based on rfcv in 'randomForest' and 'gls' in 'library(nlme)'.

Author(s)

Jin Li

References

Pinheiro, J. C. and D. M. Bates (2000). Mixed-Effects Models in S and S-PLUS. New York, Springer.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
library(nlme)

data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
range1 <- 0.8
nugget1 <- 0.5
model <- log(gravel + 1) ~  long + lat +  bathy + dist + I(long^2) + I(lat^2) +
I(lat^3) + I(bathy^2) + I(bathy^3) + I(dist^2) + I(dist^3) + I(relief^2) + I(relief^3)

glsidwcv1 <- glsidwcv(model = model, longlat = longlat, trainxy = gravel,
y = log(gravel[, 7] +1), idp = 2, nmaxidw = 12, validation = "CV",
 corr.args = corSpher(c(range1, nugget1), form = ~ lat + long, nugget = TRUE),
 predacc = "ALL")
glsidwcv1

# For glsidw
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glsidwcv1 <- glsidwcv(model = model, longlat = longlat, trainxy = gravel,
y = log(gravel[, 7] +1), idp = 2, nmaxidw = 12, validation = "CV",
corr.args = corSpher(c(range1, nugget1), form = ~ lat + long, nugget = TRUE),
predacc = "VEcv")
VEcv [i] <- glsidwcv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLSIDW", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
```

```
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

---

glsidwpred — *Generate spatial predictions using the hybrid method of generalized least squares ('gls') and inverse distance weighted ('IDW') ('glsidw')*

Description

This function is for generating spatial predictions using the hybrid method of 'gls' and 'idw' ('glsidw') (see reference #1).

Usage

```
glsidwpred(
  model = var1 ~ 1,
  longlat,
  trainxy,
  y,
  longlatpredx,
  predx,
  corr.args = NULL,
  weights = NULL,
  idp = 2,
  nmaxidw = 12,
  ...
)
```

Arguments

`model`	a formula defining the response variable and predictive variables.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be names as 'long' and 'lat'.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted. The location information must be named as 'long' and 'lat'.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`corr.args`	arguments for 'correlation' in 'gls'. See '?corClasses' in 'nlme' for details. By default, "NULL" is used. When "NULL" is used, then 'gls' is actually performing 'lm'.

`weights`	describing the within-group heteroscedasticity structure. Defaults to "NULL", corresponding to homoscedastic errors. See '?gls' in 'nlme' for details.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`...`	other arguments passed on to 'gls' and 'gstat'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Pinheiro, J. C. and D. M. Bates (2000). Mixed-Effects Models in S and S-PLUS. New York, Springer.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
library(nlme)

data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
range1 <- 0.8
nugget1 <- 0.5
model <- log(gravel + 1) ~  long + lat +  bathy + dist + I(long^2) + I(lat^2) +
I(lat^3) + I(bathy^2) + I(bathy^3) + I(dist^2) + I(dist^3) + I(relief^2) + I(relief^3)
y <- log(gravel[, 7] +1)

glsidwpred1 <- glsidwpred(model = model, longlat = longlat, trainxy = gravel,
y = y, longlatpredx = petrel.grid[, c(1:2)], predx = petrel.grid,
 idp = 2, nmaxidw = 12, corr.args = corSpher(c(range1, nugget1),
 form = ~ lat + long, nugget = TRUE))

names(glsidwpred1)

# Back transform 'glsidwpred$predictions' to generate the final predictions
glsidw.predictions <- exp(glsidwpred1$predictions) - 1
range(glsidw.predictions)
```

glskrigecv — *Cross validation, n-fold and leave-one-out for the hybrid method of generalized least squares ('gls') and kriging ('krige') ('glskrige')*

Description

This function is a cross validation function for the hybrid method of 'gls' and 'krige' ('glskrige'), where the data splitting is based on a stratified random sampling method (see the 'datasplit' function for details)

Usage

```
glskrigecv(
  model = var1 ~ 1,
  longlat,
  trainxy,
  y,
  corr.args = NULL,
  weights = NULL,
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`model`	a formula defining the response variable and predictive variables.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be names as 'long' and 'lat'.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`corr.args`	arguments for 'correlation' in 'gls'. See '?corClasses' in 'nlme' for details. By default, "NULL" is used. When "NULL" is used, then 'gls' is actually performing 'lm'.

`weights`	describing the within-group heteroscedasticity structure. Defaults to "NULL", corresponding to homoscedastic errors. See '?gls' in 'nlme' for details.
`transformation`	transform the residuals of 'gls' to normalize the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'gls' and 'krige'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only.

Note

This function is largely based on rfcv in 'randomForest', 'krigecv' in 'spm2' and 'gls' in 'library(nlme)'.

Author(s)

Jin Li

References

Pinheiro, J. C. and D. M. Bates (2000). Mixed-Effects Models in S and S-PLUS. New York, Springer.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
library(nlme)

data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
range1 <- 0.8
nugget1 <- 0.5
model <- log(gravel + 1) ~  long + lat +  bathy + dist + I(long^2) + I(lat^2) +
I(lat^3) + I(bathy^2) + I(bathy^3) + I(dist^2) + I(dist^3) + I(relief^2) + I(relief^3)

glskrigecv1 <- glskrigecv(model = model, longlat = longlat, trainxy = gravel,
y = log(gravel[, 7] +1), transformation = "none", formula.krige = res1 ~ 1,
vgm.args = "Sph", nmaxkrige = 12, validation = "CV",
 corr.args = corSpher(c(range1, nugget1), form = ~ lat + long, nugget = TRUE),
 predacc = "ALL")
glskrigecv1

# For glskrige
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glskrigecv1 <- glskrigecv(model = model, longlat = longlat, trainxy = gravel,
y = log(gravel[, 7] +1), transformation = "none", formula.krige = res1 ~ 1,
vgm.args = "Sph", nmaxok = 12, validation = "CV",
corr.args = corSpher(c(range1, nugget1), form = ~ lat + long, nugget = TRUE),
 predacc = "VEcv")
VEcv [i] <- glskrigecv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLSOK", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

---

glskrigeidwcv

Cross validation, n-fold and leave-one-out for the hybrid methods of generalised least squares ('gls'), 'kriging' and inverse distance weighted ('IDW')

Description

This function is a cross validation function for 38 hybrid methods of 'gls', 'kriging' and 'IDW', including the average of 'glskrige' and 'glsidw' ('glskrigeglsidw') and the average of 'gls', 'glskrige' and 'glsidw' ('glsglskrigeglsidw'), where 'kriging' methods include ordinary kriging ('OK'), simple kriging ('SK'), block 'OK' ('BOK') and block 'SK'('BSK') and 'IDW' also covers 'NN' and 'KNN'.. The data splitting is based on a stratified random sampling method (see the 'datasplit' function for details).

Usage

```
glskrigeidwcv(
  model = var1 ~ 1,
  longlat,
  trainxy,
  y,
  corr.args = NULL,
  weights = NULL,
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`model`	a formula defining the response variable and predictive variables.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be names as 'long' and 'lat'.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`corr.args`	arguments for 'correlation' in 'gls'. See '?corClasses' in 'nlme' for details. By default, "NULL" is used. When "NULL" is used, then 'gls' is actually performing 'lm'.
`weights`	describing the within-group heteroscedasticity structure. Defaults to "NULL", corresponding to homoscedastic errors. See '?gls' in 'nlme' for details.
`transformation`	transform the residuals of 'gls' to normalise the data for 'krige'; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.

`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`hybrid.parameter`	the default is 2 that is for 'glskrigeglsidw'; for 'glsglskrigeglsidw', it needs to be 3.
`lambda`	ranging from 0 to 2; the default is 1 for 'glskrigeglsidw' and 'glsglskrigeglsidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'glskrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'glsidw' when the default 'hybrid.parameter' is used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'gls', 'krige' and 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only.

Note

This function is largely based on rfcv in 'randomForest', 'krigecv' in 'spm2' and 'gls' in 'library(nlme)'.

Author(s)

Jin Li

References

Li, J. (2022). Spatial Predictive Modeling with R. Boca Raton, Chapman and Hall/CRC.

Pinheiro, J. C. and D. M. Bates (2000). Mixed-Effects Models in S and S-PLUS. New York, Springer.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
library(nlme)

data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
range1 <- 0.8
nugget1 <- 0.5
model <- log(gravel + 1) ~  long + lat +  bathy + dist + I(long^2) + I(lat^2) +
I(lat^3) + I(bathy^2) + I(bathy^3) + I(dist^2) + I(dist^3) + I(relief^2) + I(relief^3)

glskrigeidwcv1 <- glskrigeidwcv(model = model, longlat = longlat, trainxy = gravel,
y = log(gravel[, 7] +1), transformation = "none", formula.krige = res1 ~ 1,
vgm.args = "Sph", nmaxkrige = 12, idp = 2, nmaxidw = 12, validation = "CV",
 corr.args = corSpher(c(range1, nugget1), form = ~ lat + long, nugget = TRUE),
 predacc = "ALL")
glskrigeidwcv1

# For glskrigeglsidw
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glskrigeidwcv1 <- glskrigeidwcv(model = model, longlat = longlat, trainxy = gravel,
y = log(gravel[, 7] +1), transformation = "none", formula.krige = res1 ~ 1,
vgm.args = "Sph", nmaxkrige = 12, idp = 2, nmaxidw = 12, validation = "CV",
corr.args = corSpher(c(range1, nugget1), form = ~ lat + long, nugget = TRUE),
 predacc = "VEcv")
VEcv [i] <- glskrigeidwcv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLSOKGLSIDW", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)


# For glsglskrigeglsidw
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
glskrigeidwcv1 <- glskrigeidwcv(model = model, longlat = longlat, trainxy = gravel,
y = log(gravel[, 7] +1), transformation = "none", formula.krige = res1 ~ 1,
vgm.args = "Sph", nmaxkrige = 12, idp = 2, nmaxidw = 12, hybrid.parameter = 3,
validation = "CV", corr.args = corSpher(c(range1, nugget1), form = ~ lat + long,
 nugget = TRUE), predacc = "VEcv")
VEcv [i] <- glskrigeidwcv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for GLSOKGLSIDW", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

---

glskrigeidwpred — *Generate spatial predictions using the hybrid methods of generalised least squares ('gls'), 'kriging' and inverse distance weighted ('IDW')*

Description

This function is for generating spatial predictions using the hybrid methods of 'gls', 'kriging' and 'IDW', including all methods implemented in 'glskrigeidwcv'.

Usage

```
glskrigeidwpred(
  model = var1 ~ 1,
  longlat,
  trainxy,
  predx,
  y,
  longlatpredx,
  corr.args = NULL,
  weights = NULL,
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  ...
)
```

Arguments

`model`	a formula defining the response variable and predictive variables.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be names as 'long' and 'lat'.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted. The location information must be named as 'long' and 'lat'.
`corr.args`	arguments for 'correlation' in 'gls'. See '?corClasses' in 'nlme' for details. By default, "NULL" is used. When "NULL" is used, then 'gls' is actually performing 'lm'.
`weights`	describing the within-group heteroscedasticity structure. Defaults to "NULL", corresponding to homoscedastic errors. See '?gls' in 'nlme' for details.
`transformation`	transform the residuals of 'gls' to normalise the data for 'krige'; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`hybrid.parameter`	the default is 2 that is for 'glskrigeglsidw'; for 'glsglskrigeglsidw', it needs to be 3.

`lambda`	ranging from 0 to 2; the default is 1 for 'glskrigeglsidw' and 'glsglskrigeglsidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'glskrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'glsidw' when the default 'hybrid.parameter' is used.
`...`	other arguments passed on to 'gls', 'krige' and 'gstat'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Pinheiro, J. C. and D. M. Bates (2000). Mixed-Effects Models in S and S-PLUS. New York, Springer.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
library(nlme)

data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
range1 <- 0.8
nugget1 <- 0.5
model <- log(gravel + 1) ~  long + lat +  bathy + dist + I(long^2) + I(lat^2) +
I(lat^3) + I(bathy^2) + I(bathy^3) + I(dist^2) + I(dist^3) + I(relief^2) + I(relief^3)
y <- log(gravel[, 7] +1)

glskrigeidwpred1 <- glskrigeidwpred(model = model, longlat = longlat, trainxy = gravel,
predx = petrel.grid, y = y, longlatpredx = petrel.grid[, c(1:2)],
transformation = "none", formula.krige = res1 ~ 1, vgm.args = "Sph", nmaxkrige = 12,
idp = 2, nmaxidw = 12,  corr.args = corSpher(c(range1, nugget1),
form = ~ lat + long, nugget = TRUE))

names(glskrigeidwpred1)

# Back transform 'glskrigeidwpred$predictions' to generate the final predictions
glskrigeidw.predictions <- exp(glskrigeidwpred1$predictions) - 1
range(glskrigeidw.predictions)
```

glskrigepred	*Generate spatial predictions using the hybrid method of generalized least squares ('gls') and kriging ('krige') ('glskrige')*

Description

This function is for generating spatial predictions using the hybrid method of 'gls' and 'krige' (glskrige).

Usage

```
glskrigepred(
  model = var1 ~ 1,
  longlat,
  trainxy,
  predx,
  y,
  longlatpredx,
  corr.args = NULL,
  weights = NULL,
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  ...
)
```

Arguments

model	a formula defining the response variable and predictive variables.
longlat	a dataframe contains longitude and latitude of point samples.
trainxy	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be names as 'long' and 'lat'.
predx	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
y	a vector of the response variable in the formula, that is, the left part of the formula.
longlatpredx	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted. The location information must be named as 'long' and 'lat'.

`corr.args`	arguments for 'correlation' in 'gls'. See '?corClasses' in 'nlme' for details. By default, "NULL" is used. When "NULL" is used, then 'gls' is actually performing 'lm'.
`weights`	describing the within-group heteroscedasticity structure. Defaults to "NULL", corresponding to homoscedastic errors. See '?gls' in 'nlme' for details.
`transformation`	transform the residuals of 'gls' to normalize the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`...`	other arguments passed on to 'gls' and 'krige'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Pinheiro, J. C. and D. M. Bates (2000). Mixed-Effects Models in S and S-PLUS. New York, Springer.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
library(nlme)

data(petrel)
data(petrel.grid)
```

```
gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
range1 <- 0.8
nugget1 <- 0.5
model <- log(gravel + 1) ~  long + lat +  bathy + dist + I(long^2) + I(lat^2) +
I(lat^3) + I(bathy^2) + I(bathy^3) + I(dist^2) + I(dist^3) + I(relief^2) + I(relief^3)
y <- log(gravel[, 7] +1)

glskrigepred1 <- glskrigepred(model = model, longlat = longlat, trainxy = gravel,
predx = petrel.grid, y = y, longlatpredx = petrel.grid[, c(1:2)],
transformation = "none", formula.krige = res1 ~ 1,
vgm.args = "Sph", nmaxkrige = 12, corr.args = corSpher(c(range1, nugget1),
form = ~ lat + long, nugget = TRUE))

names(glskrigepred1)

# Back transform 'glskrigepred$predictions' to generate the final predictions
glskrige.predictions <- exp(glskrigepred1$predictions) - 1
range(glskrige.predictions)
```

glspred *Generate spatial predictions using generalized least squares ('gls')*

Description

This function is for generating spatial predictions using 'gls' method in 'nlme' package.

Usage

```
glspred(
  model = var1 ~ 1,
  trainxy,
  longlatpredx,
  predx,
  corr.args = NULL,
  weights = NULL,
  ...
)
```

Arguments

`model`	a formula defining the response variable and predictive variables.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be names as 'long' and 'lat'.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted, need to be named as 'long' and 'lat'.

`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`corr.args`	arguments for 'correlation' in 'gls'. See '?corClasses' in 'nlme' for details. By default, "NULL" is used. When "NULL" is used, then 'gls' is actually performing 'lm'.
`weights`	describing the within-group heteroscedasticity structure. Defaults to "NULL", corresponding to homoscedastic errors. See '?gls' in 'nlme' for details.
`...`	other arguments passed on to 'gls'.

Value

A dataframe of longitude, latitude and predictions.

Author(s)

Jin Li

References

Pinheiro, J. C. and D. M. Bates (2000). Mixed-Effects Models in S and S-PLUS. New York, Springer.

Examples

```
library(spm)
library(nlme)

data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
range1 <- 0.8
nugget1 <- 0.5

model <- log(gravel + 1) ~  long + lat +  bathy + dist + I(long^2) + I(lat^2) +
I(lat^3) + I(bathy^2) + I(bathy^3) + I(dist^2) + I(dist^3) + I(relief^2) + I(relief^3)

glspred1 <- glspred(model = model, trainxy = gravel,
 longlatpredx = petrel.grid[, c(1:2)], predx = petrel.grid,
 corr.args = corSpher(c(range1, nugget1), form = ~ lat + long, nugget = TRUE))

names(glspred1)

# Back transform 'glspred1$predictions' to generate the final predictions
gls.predictions <- exp(glspred1$predictions) - 1
range(gls.predictions)
```

krigecv	*Cross validation, n-fold and leave-one-out for kriging methods ('krige')*

Description

This function is a cross validation function for kriging methods ('krige') in 'gstat'.

Usage

```
krigecv(
  longlat,
  trainy,
  trainpredx = NULL,
  validation = "CV",
  cv.fold = 10,
  nmax = 12,
  transformation = "none",
  delta = 1,
  formula = var1 ~ 1,
  vgm.args = ("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  predacc = "VEcv",
  ...
)
```

Arguments

`longlat`	a dataframe contains longitude and latitude of point samples.
`trainy`	a vector of response, must have length equal to the number of rows in trainx.
`trainpredx`	a dataframe contains predictive variables of point samples. If longitude and latitude are going to be used as predictive variables, they should also be included but they should be named in names other than 'long' and 'lat'.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`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, 12 observations are used.
`transformation`	transform response variable to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.

`delta`	numeric; to avoid 'log(0)' in "log" transformation. The default is 1.
`formula`	formula defining response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in the 'gstat' package for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in the 'gstat' package for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in the 'gstat' package for details.
`alpha`	direction in plane (x,y). see variogram in the 'gstat' package for details.
`block`	block size. see 'krige' in the 'gstat' package for details.
`beta`	for simple kriging. see 'krige' in the 'gstat' package for details.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to the function 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on rfcv in 'randomForest' and some functions in 'library(gstat)'. When 'A zero or negative range was fitted to variogram' occurs, to allow 'gstat' running, the range was set to be positive by using 'min(vgm1$dist)'. In this case, caution should be taken in applying this method. If it still occurs for 'okpred' function, different method may need to be used.

Author(s)

Jin Li

References

Li, J., 2013. Predictive Modelling Using Random Forest and Its Hybrid Methods with Geostatistical Techniques in Marine Environmental Geosciences, In: Christen, P., Kennedy, P., Liu, L., Ong, K.-L., Stranieri, A., Zhao, Y. (Eds.), The proceedings of the Eleventh Australasian Data Mining Conference (AusDM 2013), Canberra, Australia, 13-15 November 2013. Conferences in Research and Practice in Information Technology, Vol. 146.

A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18-22.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(sp)
library(spm)
data(swmud)
data(petrel)

set.seed(1234)
okcv1 <- krigecv(longlat = swmud[, c(1,2)], trainy = swmud[, 3], nmax = 7, transformation =
"arcsine", vgm.args = ("Sph"), predacc = "VEcv")
okcv1

set.seed(1234)
skcv1 <- krigecv(longlat = swmud[, c(1,2)], trainy = swmud[, 3], nmax = 7, transformation =
"arcsine", vgm.args = ("Sph"), predacc = "VEcv", beta = mean(swmud[, 3]))
skcv1

set.seed(1234)
ukcv1 <- krigecv(longlat = swmud[, c(1,2)], trainy = swmud[, 3], nmax = 7, transformation =
"arcsine", formula = var1 ~ long + lat, vgm.args = ("Sph"), predacc = "VEcv")
ukcv1

set.seed(1234)
okcv2 <- krigecv(longlat = swmud[, c(1,2)], trainy = swmud[, 3], validation = "LOO", nmax = 7,
transformation = "arcsine", vgm.args = ("Sph"), predacc = "ALL")
okcv2

set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
okcv1 <- krigecv(longlat = petrel[, c(1,2)], trainy = petrel[, 5], nmax = 12,
transformation = "arcsine", predacc = "VEcv")
VEcv [i] <- okcv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for OK", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)

set.seed(1234)
n <- 20 # number of iterations, 60 to 100 is recommended.
measures <- NULL
for (i in 1:n) {
okcv1 <- krigecv(longlat = petrel[, c(1,2)], trainy = petrel[, 3], nmax = 12, transformation =
"arcsine", predacc = "ALL")
measures <- rbind(measures, okcv1$vecv)
}
plot(measures ~ c(1:n), xlab = "Iteration for OK", ylab = "VEcv (%)")
points(cumsum(measures) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(measures), col = 'blue', lwd = 2)
```

krigepred *Generate spatial predictions using kriging methods ('krige')*

Description

This function is to make spatial predictions using kriging methods ('krige').

Usage

```
krigepred(
  trainx,
  trainy,
  trainx2,
  nmax = 12,
  transformation = "none",
  delta = 1,
  formula = var1 ~ 1,
  vgm.args = ("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  ...
)
```

Arguments

`trainx`	a dataframe contains longitude (long), latitude (lat) and predictive variables of point samples. The location information must be named as 'long' and 'lat'.
`trainy`	a vector of response, must have length equal to the number of rows in trainx.
`trainx2`	a dataframe contains longitude (long), latitude (lat) and predictive variables of point locations (i.e., the centres of grids) to be predicted. The location information must be named as 'long' and 'lat' and in the first two columns respectively..
`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, 12 observations are used.
`transformation`	transform the response variable to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation.
`formula`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in gstat for details.
`vgm.args`	arguments for vgm, e.g. variogram model of response variable and anisotropy parameters. see notes vgm in gstat for details. By default, "Sph" is used.

`anis`	anisotropy parameters: see notes vgm in gstat for details.
`alpha`	direction in plane (x,y). see variogram in gstat for details.
`block`	block size. see krige in gstat for details.
`beta`	for simple kriging. see krige in gstat for details.
`...`	other arguments passed on to gstat.

Value

A dataframe of longitude, latitude, predictions and variances.

Note

The variances in the output are not transformed back when a transformation is used. This is because kriging variances are not measuring the uncertainty of predictions but they are indicator of the spatial distribution of sample density. The variances are exported only for interested users; and if needed, they can be transformed back from the output.

Author(s)

Jin Li

References

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(sp)
library(spm)
data(swmud)
data(sw)
okpred1 <- krigepred(swmud[, c(1,2)], swmud[, 3], sw, nmax = 7, transformation =
"arcsine", vgm.args = ("Sph"))
names(okpred1)
```

`rfkrigeidwcv` *Cross validation, n-fold and leave-one-out for the hybrid methods of 'random forest' ('RF'), 'kriging' and inverse distance weighted ('IDW')*

Description

This function is a cross validation function for 38 hybrid methods of 'RF', 'kriging' and 'IDW', including the average of 'rfkrige' and 'rfidw' ('rfkrigerfidw') and the average of 'rf', 'rfkrige' and 'rfidw' ('rfrfkrigerfidw'), where 'kriging' methods include ordinary kriging ('OK'), simple kriging ('SK'), block 'OK' ('BOK') and block 'SK'('BSK') and 'IDW' also covers 'NN' and 'KNN'.. The data splitting is based on a stratified random sampling method (see the 'datasplit' function for details).

Usage

```
rfkrigeidwcv(
  longlat,
  trainx,
  trainy,
  mtry = function(p) max(1, floor(sqrt(p))),
  ntree = 500,
  transformation = "none",
  delta = 1,
  formula = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`longlat`	a dataframe contains longitude and latitude of point samples.
`trainx`	a dataframe or matrix contains columns of predictive variables.
`trainy`	a vector of the response variable.
`mtry`	a function of number of remaining predictor variables to use as the 'mtry' parameter in the 'randomForest' call.
`ntree`	number of trees to grow. This should not be set to too small a number, to ensure that every input row gets predicted at least a few times. By default, 500 is used.
`transformation`	transform the residuals of 'rf' to normalize the data for 'krige'; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.

`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`hybrid.parameter`	the default is 2 that is for 'rfkrigerfidw'; for 'rfrfkrigerfidw', it needs to be 3.
`lambda`	ranging from 0 to 2; the default is 1 for 'rfkrigerfidw' and 'rfrfkrigerfidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'rfkrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'rfidw' when the default 'hybrid.parameter' is used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'randomForest', 'krige' and 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'rfcv' in 'randomForest', and 'krigecv' in 'spm2'.

Author(s)

Jin Li

References

Li, J. (2022). Spatial Predictive Modeling with R. Boca Raton, Chapman and Hall/CRC.

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

Liaw, A. and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18-22.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
# rfrfokrfidw
data(sponge)
longlat <- sponge[, 1:2]
set.seed(1234)
rfrfkrigerfidwcv1 <- rfkrigeidwcv(longlat = longlat,
trainx = sponge[, -3], trainy = sponge[, 3], formula = res1 ~ 1, vgm.args = ("Sph"),
nmaxkrige = 12, idp = 2, nmaxidw = 12, hybrid.parameter = 3, validation = "CV",
predacc = "ALL")
rfrfkrigerfidwcv1

# rfokrfidw for count data
data(sponge)
longlat <- sponge2[, 1:2]
y = sponge[, 3]
trainx = sponge[, -3]
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
 rfkrigerfidwcv1 <- rfkrigeidwcv(longlat = longlat,
 trainx = trainx, trainy = y, formula = res1 ~ 1, vgm.args = ("Sph"),
 nmaxkrige = 12, idp = 2, nmaxidw = 12, validation = "CV",  predacc = "VEcv")
 VEcv [i] <- rfkrigerfidwcv1
 }
 plot(VEcv ~ c(1:n), xlab = "Iteration for rfokrfidw", ylab = "VEcv (%)")
 points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
 abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

rfkrigeidwpred — *Generate spatial predictions using the hybrid methods of 'random forest' ('RF'), 'kriging' and inverse distance weighted ('IDW').*

Description

This function is for generating spatial predictions using the hybrid methods of 'RF', 'kriging' and 'IDW', including all methods implemented in 'rfkrigeidwcv'.

Usage

```
rfkrigeidwpred(
  longlat,
  trainx,
  predx,
  trainy,
  longlatpredx,
  mtry = function(p) max(1, floor(sqrt(p))),
  ntree = 500,
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  ...
)
```

Arguments

`longlat`	a dataframe contains longitude and latitude of point samples.
`trainx`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be named as 'long' and 'lat'.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`trainy`	a vector of the response variable in the formula, that is, the left part of the formula.

`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted.
`mtry`	a function of number of remaining predictor variables to use as the 'mtry' parameter in the 'randomForest' call.
`ntree`	number of trees to grow. This should not be set to too small a number, to ensure that every input row gets predicted at least a few times. By default, 500 is used. #' @param longlatpredx a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted. The location information must be named as 'long' and 'lat'.
`transformation`	transform the residuals of 'rf' to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`hybrid.parameter`	the default is 2 that is for 'rfkrigerfidw'; for 'rfrfkrigerfidw', it needs to be 3.
`lambda`	ranging from 0 to 2; the default is 1 for 'rfkrigerfidw' and 'rfrfkrigerfidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'rfkrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'rfidw' when the default 'hybrid.parameter' is used.
`...`	other arguments passed on to 'rf', 'krige' and 'gstat'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

Liaw, A. and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18-22.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(sponge)
data(sponge.grid)
longlat <- sponge[, 1:2]
y = sponge[, 3]
trainx = sponge[, -3]

set.seed(1234)

rfkrigeidwpred1 <- rfkrigeidwpred(longlat = longlat, trainx =  trainx,
predx = sponge.grid, trainy = y, longlatpredx = sponge.grid[, c(1:2)],
formula.krige = res1 ~ 1, vgm.args = "Sph", nmaxkrige = 12, idp = 2, nmaxidw = 12)

names(rfkrigeidwpred1)

range(rfkrigeidwpred1$predictions)
```

`sponge2` *A dataset of sponge species richness in the Timor Sea region, northern Australia marine margin*

Description

This dataset contains 77 samples of 81 variables including easting (longitude), northing (latitude), bathy, backscatter and their derived variables.

Usage

```
data("sponge2")
```

Format

A data frame with 77 observations on the following 89 variables.

`easting`	a numeric vector, m
`northing`	a numeric vector, m
`species.richness`	a numeric vector, no unit
`mud`	a numeric vector, percentage
`sand`	a numeric vector, percentage
`gravel`	a numeric vector, percentage
`bathy`	a numeric vector, m
`bs25`	a numeric vector, dB
`bs10`	a numeric vector, dB
`bs11`	a numeric vector, dB
`bs12`	a numeric vector, dB
`bs13`	a numeric vector, dB
`bs14`	a numeric vector, dB
`bs15`	a numeric vector, dB
`bs16`	a numeric vector, dB
`bs17`	a numeric vector, dB
`bs18`	a numeric vector, dB
`bs19`	a numeric vector, dB
`bs20`	a numeric vector, dB
`bs21`	a numeric vector, dB
`bs22`	a numeric vector, dB
`bs23`	a numeric vector, dB
`bs24`	a numeric vector, dB
`bs26`	a numeric vector, dB
`bs27`	a numeric vector, dB
`bs28`	a numeric vector, dB
`bs29`	a numeric vector, dB
`bs30`	a numeric vector, dB
`bs31`	a numeric vector, dB
`bs32`	a numeric vector, dB
`bs33`	a numeric vector, dB
`bs34`	a numeric vector, dB
`bs35`	a numeric vector, dB
`bs36`	a numeric vector, dB
`bs_o`	a numeric vector, dB

`bs_homo_o` a numeric vector

`bs_entro_o` a numeric vector, no unit

`bs_var_o` a numeric vector, dB^2

`bs_lmi_o` a numeric vector

`bathy_o` a numeric vector, m

`bathy_lmi_o` a numeric vector

`tpi_o` a numeric vector, no unit

`slope_o` a numeric vector

`plan_cur_o` a numeric vector

`prof_cur_o` a numeric vector

`relief_o` a numeric vector

`rugosity_o` a numeric vector

`dist.coast` a numeric vector, m

`rugosity3` a numeric vector

`rugosity5` a numeric vector

`rugosity7` a numeric vector

`tpi3` a numeric vector, no unit

`tpi5` a numeric vector, no unit

`tpi7` a numeric vector, no unit

`bathy_lmi3` a numeric vector

`bathy_lmi5` a numeric vector

`bathy_lmi7` a numeric vector

`plan_curv3` a numeric vector

`plan_curv5` a numeric vector

`plan_curv7` a numeric vector

`relief_3` a numeric vector

`relief_5` a numeric vector

`relief_7` a numeric vector

`slope3` a numeric vector

`slope5` a numeric vector

`slope7` a numeric vector

`prof_cur3` a numeric vector

`prof_cur5` a numeric vector

`prof_cur7` a numeric vector

`entro3` a numeric vector, no unit

`entro5` a numeric vector, no unit

`entro7` a numeric vector, no unit

`homo3` a numeric vector

`homo5` a numeric vector

`homo7` a numeric vector

`var3` a numeric vector, dB^2

`var5` a numeric vector, dB^2

`var7` a numeric vector, dB^2

`bs_lmi3` a numeric vector

`bs_lmi5` a numeric vector

`bs_lmi7` a numeric vector

Details

For details, please see the source. This dataset was published as an appendix of the paper listed in the source. Where the long and lat were reprojected to easting and northing.

Source

see Appendix A-D. Supplementary data at: "http://dx.doi.org/10.1016/j.envsoft.2017.07.016."

References

Li, J., B. Alvarez, J. Siwabessy, M. Tran, Z. Huang, R. Przeslawski, L. Radke, F. Howard, and S. Nichol. 2017. Application of random forest, generalised linear model and their hybrid methods with geostatistical techniques to count data: Predicting sponge species richness. Environmental Modelling & Software, 97: 112-129.

`spongelonglat` *A dataset of sponge species richness in the Timor Sea region, northern Australia marine margin*

Description

This dataset contains 77 samples of 7 predictive variables including longitude, latitude, bathy, backscatter and their derived variables. It is the sponge dataset in ‘spm‘ package, but with long and lat instead of easting and northing.

Usage

```
data("spongelonglat")
```

Format

A data frame with 77 observations on the following 8 variables.

`sponge`	a numeric vector
`tpi3`	a numeric vector
`var7`	a numeric vector
`entro7`	a numeric vector
`bs34`	a numeric vector
`bs11`	a numeric vector
`long`	a numeric vector
`lat`	a numeric vector

Details

For details, please see sponge dataset in library(spm). Where the long and lat were projected to easting and northing.

Source

sponge dataset in library(spm)

References

Li, J., B. Alvarez, J. Siwabessy, M. Tran, Z. Huang, R. Przeslawski, L. Radke, F. Howard, and S. Nichol. 2017. Application of random forest, generalised linear model and their hybrid methods with geostatistical techniques to count data: Predicting sponge species richness. Environmental Modelling & Software, 97: 112-129.

Examples

```
data(spongelonglat)
## maybe str(spongelonglat) ; plot(spongelonglat) ...
```

`svmcv` *Cross validation, n-fold and leave-one-out for support vector machine ('svm')*

Description

This function is a cross validation function for 'svm' regression in 'e1071' package.

Usage

```
svmcv(
  formula = NULL,
  trainxy,
  y,
  scale = TRUE,
  type = NULL,
  kernel = "radial",
  degree = 3,
  gamma = if (is.vector(trainxy)) 1 else 1/ncol(trainxy),
  coef0 = 0,
  cost = 1,
  nu = 0.5,
  tolerance = 0.001,
  epsilon = 0.1,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`formula`	a formula defining the response variable and predictive variables.
`trainxy`	a dataframe contains predictive variables and the response variable of point samples. The location information, longitude (long), latitude (lat), need to be included in the 'trainx' for spatial predictive modelling, need to be named as 'long' and 'lat'.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`scale`	A logical vector indicating the variables to be scaled (default: TRUE).
`type`	the default setting is 'NULL'. See '?svm' for various options.
`kernel`	the default setting is 'radial'. See '?svm' for other options.
`degree`	a parameter needed for kernel of type polynomial (default: 3).
`gamma`	a parameter needed for all 'kernels' except 'linear' (default: 1/(data dimension)).
`coef0`	a parameter needed for kernels of type 'polynomial' and 'sigmoid'(default: 0).
`cost`	cost of constraints violation (default: 1).
`nu`	a parameter needed for 'nu-classification', 'nu-regression', and 'one-classification' (default: 0.5).
`tolerance`	tolerance of termination criterion (default: 0.001).
`epsilon`	'epsilon' in the insensitive-loss function (default: 0.1).
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.

`predacc`	can be either "VEcv" for 'vecv' or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'svm'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'rfcv' in 'randomForest' and 'svm' in 'e1071'.

Author(s)

Jin Li

References

David Meyer, Evgenia Dimitriadou, Kurt Hornik, Andreas Weingessel and Friedrich Leisch (2020). e1071: Misc Functions of the Department of Statistics, Probability Theory Group (Formerly: E1071), TU Wien. R package version 1.7-4. https://CRAN.R-project.org/package=e1071.

Examples

```
library(spm)

data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
model <- log(gravel + 1) ~ lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
set.seed(1234)
svmcv1 <- svmcv(formula = model, gravel, log(gravel[, 7] +1), validation = "CV",
 predacc = "ALL")
svmcv1

data(sponge2)
model <- species.richness ~ .
set.seed(1234)
svmcv1 <- svmcv(formula = model, sponge2[, -4], sponge[, 3], gamma = 0.01, cost = 3.5,
scale = TRUE, validation = "CV",  predacc = "VEcv")
svmcv1

# For svm
model <- species.richness ~ .
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
svmcv1 <- svmcv(formula = model, sponge2[, -4], sponge[, 3], gamma = 0.01, cost = 3.5,
scale = TRUE, validation = "CV",  predacc = "VEcv")
VEcv [i] <- svmcv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for svm", ylab = "VEcv (%)")
```

```
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

svmidwcv *Cross validation, n-fold and leave-one-out for the hybrid method of support vector machine ('svm') regression and inverse distance weighted ('IDW') (svmidw)*

Description

This function is a cross validation function for the hybrid method of 'svm' regression and 'idw' using 'gstat' (svmidw), where the data splitting is based on a stratified random sampling method (see the 'datasplit' function for details).

Usage

```
svmidwcv(
  formula = NULL,
  longlat,
  trainxy,
  y,
  scale = TRUE,
  type = NULL,
  kernel = "radial",
  degree = 3,
  gamma = if (is.vector(trainxy)) 1 else 1/ncol(trainxy),
  coef0 = 0,
  cost = 1,
  nu = 0.5,
  tolerance = 0.001,
  epsilon = 0.1,
  idp = 2,
  nmaxidw = 12,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`formula`	a formula defining the response variable and predictive variables for 'svm'.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be named as 'long' and 'lat'.

`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`scale`	A logical vector indicating the variables to be scaled (default: TRUE).
`type`	the default setting is 'NULL'. See '?svm' for various options.
`kernel`	the default setting is 'radial'. See '?svm' for other options.
`degree`	a parameter needed for kernel of type polynomial (default: 3).
`gamma`	a parameter needed for all 'kernels' except 'linear' (default: 1/(data dimension)).
`coef0`	a parameter needed for kernels of type 'polynomial' and 'sigmoid'(default: 0).
`cost`	cost of constraints violation (default: 1).
`nu`	a parameter needed for 'nu-classification', 'nu-regression', and 'one-classification' (default: 0.5).
`tolerance`	tolerance of termination criterion (default: 0.001).
`epsilon`	'epsilon' in the insensitive-loss function (default: 0.1).
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for 'vecv' or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'svm' and 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only.

Note

This function is largely based on 'rfcv' in 'randomForest', 'idwcv' in 'spm'and 'svm' in 'e1071'.

Author(s)

Jin Li

References

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

David Meyer, Evgenia Dimitriadou, Kurt Hornik, Andreas Weingessel and Friedrich Leisch (2020). e1071: Misc Functions of the Department of Statistics, Probability Theory Group (Formerly: E1071), TU Wien. R package version 1.7-4. https://CRAN.R-project.org/package=e1071.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)

set.seed(1234)
svmidwcv1 <- svmidwcv(formula = model, longlat = longlat, trainxy =  gravel,
y = y, idp = 2, nmaxidw = 12, validation = "CV", predacc = "ALL")
svmidwcv1

# svmidw for count data
data(sponge2)
model <- species.richness ~ . # use all predictive variables in the dataset
longlat <- sponge2[, 1:2]
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
 svmidwcv1 <- svmidwcv(formula = model, longlat = longlat, trainxy = sponge2[, -4],
 y = sponge[, 3], gamma = 0.01,  cost = 3.5, scale = TRUE, idp = 2, nmaxidw = 12,
 validation = "CV", predacc = "VEcv")
 VEcv [i] <- svmidwcv1
 }
 plot(VEcv ~ c(1:n), xlab = "Iteration for svmidw", ylab = "VEcv (%)")
 points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
 abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

---

svmidwpred *Generate spatial predictions using the hybrid method of support vector machine ('svm') regression and inverse distance weighted ('IDW') ('svmidw')*

Description

This function is for generating spatial predictions using the hybrid method of 'svm' and 'idw' ('svmidw').

Usage

```
svmidwpred(
  formula = NULL,
  longlat,
  trainxy,
  y,
  longlatpredx,
  predx,
  scale = TRUE,
  type = NULL,
  kernel = "radial",
  degree = 3,
  gamma = if (is.vector(trainxy)) 1 else 1/ncol(trainxy),
  coef0 = 0,
  cost = 1,
  nu = 0.5,
  tolerance = 0.001,
  epsilon = 0.1,
  idp = 2,
  nmaxidw = 12,
  ...
)
```

Arguments

`formula`	a formula defining the response variable and predictive variables for 'svm'.
`longlat`	a dataframe contains longitude and latitude of point samples. The location information must be named as 'long' and 'lat'.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`scale`	A logical vector indicating the variables to be scaled (default: TRUE).
`type`	the default setting is 'NULL'. See '?svm' for various options.
`kernel`	the default setting is 'radial'. See '?svm' for other options.
`degree`	a parameter needed for kernel of type polynomial (default: 3).
`gamma`	a parameter needed for all 'kernels' except 'linear' (default: 1/(data dimension)).
`coef0`	a parameter needed for kernels of type 'polynomial' and 'sigmoid'(default: 0).
`cost`	cost of constraints violation (default: 1).
`nu`	a parameter needed for 'nu-classification', 'nu-regression', and 'one-classification' (default: 0.5).

`tolerance`	tolerance of termination criterion (default: 0.001).
`epsilon`	'epsilon' in the insensitive-loss function (default: 0.1). See '?svm' for details.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`...`	other arguments passed on to 'svm'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

David Meyer, Evgenia Dimitriadou, Kurt Hornik, Andreas Weingessel and Friedrich Leisch (2020). e1071: Misc Functions of the Department of Statistics, Probability Theory Group (Formerly: E1071), TU Wien. R package version 1.7-4. https://CRAN.R-project.org/package=e1071.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)

svmidwpred1 <- svmidwpred(formula = model, longlat = longlat, trainxy =  gravel,
y = y, longlatpredx = petrel.grid[, c(1:2)], predx = petrel.grid, idp = 2,
 nmaxidw = 12)

names(svmidwpred1)

# Back transform 'svmidwpred$predictions' to generate the final predictions
svmidw.predictions <- exp(svmidwpred1$predictions) - 1
```

```
range(svmidw.predictions)
```

svmkrigecv *Cross validation, n-fold and leave-one-out for the hybrid method of support vector machine ('svm') regression and 'krige' (svmkrige)*

Description

This function is a cross validation function for the hybrid method of 'svm' regression and 'krige' (svmkrige), where the data splitting is based on a stratified random sampling method (see the 'datasplit' function for details).

Usage

```
svmkrigecv(
  formula.svm = NULL,
  longlat,
  trainxy,
  y,
  scale = TRUE,
  type = NULL,
  kernel = "radial",
  degree = 3,
  gamma = if (is.vector(trainxy)) 1 else 1/ncol(trainxy),
  coef0 = 0,
  cost = 1,
  nu = 0.5,
  tolerance = 0.001,
  epsilon = 0.1,
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`formula.svm`	a formula defining the response variable and predictive variables for 'svm'.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be named as 'long' and 'lat'.
`y`	a vector of the response variable in the formula.svm, that is, the left part of the formula.svm.
`scale`	A logical vector indicating the variables to be scaled (default: TRUE).
`type`	the default setting is 'NULL'. See '?svm' for various options.
`kernel`	the default setting is 'radial'. See '?svm' for other options.
`degree`	a parameter needed for kernel of type polynomial (default: 3).
`gamma`	a parameter needed for all 'kernels' except 'linear' (default: 1/(data dimension)).
`coef0`	a parameter needed for kernels of type 'polynomial' and 'sigmoid'(default: 0).
`cost`	cost of constraints violation (default: 1).
`nu`	a parameter needed for 'nu-classification', 'nu-regression', and 'one-classification' (default: 0.5).
`tolerance`	tolerance of termination criterion (default: 0.001).
`epsilon`	'epsilon' in the insensitive-loss function (default: 0.1).
`transformation`	transform the residuals of 'svm' to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for 'vecv' or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'svm' and 'krige'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'rfcv' in 'randomForest', 'krigecv' in 'spm2'and 'svm' in 'e1071'.

Author(s)

Jin Li

References

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

David Meyer, Evgenia Dimitriadou, Kurt Hornik, Andreas Weingessel and Friedrich Leisch (2020). e1071: Misc Functions of the Department of Statistics, Probability Theory Group (Formerly: E1071), TU Wien. R package version 1.7-4. https://CRAN.R-project.org/package=e1071.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(petrel)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)
set.seed(1234)
svmkrigecv1 <- svmkrigecv(formula.svm = model, longlat = longlat, trainxy =  gravel,
y = y, transformation = "none", formula.krige = res1 ~ 1, vgm.args = "Sph",
nmaxkrige = 12, validation = "CV", predacc = "ALL")
svmkrigecv1

# svmok for count data
data(sponge2)
model <- species.richness ~ . # use all predictive variables in the dataset
longlat <- sponge2[, 1:2]
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
```

```
svmkrigecv1 <- svmkrigecv(formula.svm = model, longlat = longlat, trainxy = sponge2[, -4],
y = sponge2[, 3], gamma = 0.01, cost = 3.5, scale = TRUE,  formula.krige = res1 ~ 1,
vgm.args = ("Sph"), nmaxkrige = 12,  validation = "CV",  predacc = "VEcv")
VEcv [i] <- svmkrigecv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for svm", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

svmkrigeidwcv — *Cross validation, n-fold and leave-one-out for the hybrid methods of support vector machine ('svm') regression , 'kriging' and inverse distance weighted ('IDW').*

Description

This function is a cross validation function for 38 hybrid methods of 'svm', 'kriging' and 'IDW', including the average of 'svmkrige' and 'svmidw' ('svmkrigesvmidw') and the average of 'svm', 'svmkrige' and 'svmidw' ('svmsvmkrigesvmidw'), where 'kriging' methods include ordinary kriging ('OK'), simple kriging ('SK'), block 'OK' ('BOK') and block 'SK'('BSK') and 'IDW' also covers 'NN' and 'KNN'.. The data splitting is based on a stratified random sampling method (see the 'datasplit' function for details).

Usage

```
svmkrigeidwcv(
  formula.svm = NULL,
  longlat,
  trainxy,
  y,
  scale = TRUE,
  type = NULL,
  kernel = "radial",
  degree = 3,
  gamma = if (is.vector(trainxy)) 1 else 1/ncol(trainxy),
  coef0 = 0,
  cost = 1,
  nu = 0.5,
  tolerance = 0.001,
  epsilon = 0.1,
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`formula.svm`	a formula defining the response variable and predictive variables for 'svm'.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples. That is, the location information must be named as 'long' and 'lat'.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`scale`	A logical vector indicating the variables to be scaled (default: TRUE).
`type`	the default setting is 'NULL'. See '?svm' for various options.
`kernel`	the default setting is 'radial'. See '?svm' for other options.
`degree`	a parameter needed for kernel of type polynomial (default: 3).
`gamma`	a parameter needed for all 'kernels' except 'linear' (default: 1/(data dimension)).
`coef0`	a parameter needed for kernels of type 'polynomial' and 'sigmoid'(default: 0).
`cost`	cost of constraints violation (default: 1).
`nu`	a parameter needed for 'nu-classification', 'nu-regression', and 'one-classification' (default: 0.5).
`tolerance`	tolerance of termination criterion (default: 0.001).
`epsilon`	'epsilon' in the insensitive-loss function (default: 0.1).
`transformation`	transform the residuals of 'svm' to normalise the data for 'krige'; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.

`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`idp`	a numeric number specifying the inverse distance weighting power.
`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`hybrid.parameter`	the default is 2 that is for 'svmkrigesvmidw'; for 'svmsvmkrigesvmidw', it needs to be 3.
`lambda`	ranging from 0 to 2; the default is 1 for 'svmkrigesvmidw' and 'svmsvmkrigesvmidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'svmkrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'svmidw' when the default 'hybrid.parameter' is used.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'svm', 'krige' and 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'rfcv' in 'randomForest', 'krigecv' in 'spm2'and 'svm' in 'e1071'.

Author(s)

Jin Li

References

Li, J. (2022). Spatial Predictive Modeling with R. Boca Raton, Chapman and Hall/CRC.

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

David Meyer, Evgenia Dimitriadou, Kurt Hornik, Andreas Weingessel and Friedrich Leisch (2020). e1071: Misc Functions of the Department of Statistics, Probability Theory Group (Formerly: E1071), TU Wien. R package version 1.7-4. https://CRAN.R-project.org/package=e1071.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)
# svmokglidw
data(petrel)
gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)
set.seed(1234)
svmkrigesvmidwcv1 <- svmkrigeidwcv(formula.svm = model, longlat = longlat,
trainxy =  gravel, y = y, transformation = "none", formula.krige = res1 ~ 1,
vgm.args = "Sph", nmaxkrige = 12, idp = 2, nmaxidw = 12, validation = "CV",
 predacc = "ALL")
svmkrigesvmidwcv1

# svmsvmoksvmidw
data(sponge2)
model <- species.richness ~ . # use all predictive variables in the dataset
longlat <- sponge2[, 1:2]
y = sponge[, 3]
set.seed(1234)
svmsvmkrigesvmidwcv1 <- svmkrigeidwcv(formula.svm = model, longlat = longlat,
trainxy = sponge2[, -4], y = y, gamma = 0.01, cost = 3.5, scale = TRUE,
formula.krige = res1 ~ 1, vgm.args = ("Sph"), nmaxkrige = 12, idp = 2,
nmaxidw = 12, hybrid.parameter = 3, validation = "CV", predacc = "ALL")
svmsvmkrigesvmidwcv1

# svmoksvmidw for count data
data(sponge2)
model <- species.richness ~ . # use all predictive variables in the dataset
longlat <- sponge2[, 1:2]
y = sponge2[, 3]
set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
 svmkrigesvmidwcv1 <- svmkrigeidwcv(formula.svm = model, longlat = longlat,
 trainxy = sponge2[, -4], y = y, gamma = 0.01, cost = 3.5, scale = TRUE,
 formula.krige = res1 ~ 1, vgm.args = ("Sph"), nmaxkrige = 12, idp = 2,
 nmaxidw = 12, validation = "CV",  predacc = "VEcv")
 VEcv [i] <- svmkrigesvmidwcv1
 }
 plot(VEcv ~ c(1:n), xlab = "Iteration for svm", ylab = "VEcv (%)")
 points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
 abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

svmkrigeidwpred *Generate spatial predictions using the hybrid methods of support vector machine ('svm') regression , 'kriging' and inverse distance weighted ('IDW').*

Description

This function is for generating spatial predictions using the hybrid methods of 'svm', 'kriging' and 'IDW', including all methods implemented in 'svmkrigeidwcv'.

Usage

```
svmkrigeidwpred(
  formula.svm = NULL,
  longlat,
  trainxy,
  predx,
  y,
  longlatpredx,
  scale = TRUE,
  type = NULL,
  kernel = "radial",
  degree = 3,
  gamma = if (is.vector(trainxy)) 1 else 1/ncol(trainxy),
  coef0 = 0,
  cost = 1,
  nu = 0.5,
  tolerance = 0.001,
  epsilon = 0.1,
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  idp = 2,
  nmaxidw = 12,
  hybrid.parameter = 2,
  lambda = 1,
  ...
)
```

Arguments

`formula.svm`	a formula defining the response variable and predictive variables for 'svm'.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted.
`scale`	A logical vector indicating the variables to be scaled (default: TRUE).
`type`	the default setting is 'NULL'. See '?svm' for various options.
`kernel`	the default setting is 'radial'. See '?svm' for other options.
`degree`	a parameter needed for kernel of type polynomial (default: 3).
`gamma`	a parameter needed for all 'kernels' except 'linear' (default: 1/(data dimension)).
`coef0`	a parameter needed for kernels of type 'polynomial' and 'sigmoid'(default: 0).
`cost`	cost of constraints violation (default: 1).
`nu`	a parameter needed for 'nu-classification', 'nu-regression', and 'one-classification' (default: 0.5).
`tolerance`	tolerance of termination criterion (default: 0.001).
`epsilon`	'epsilon' in the insensitive-loss function (default: 0.1). See '?svm' for details.
`transformation`	transform the residuals of 'svm' to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`idp`	a numeric number specifying the inverse distance weighting power.

`nmaxidw`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`hybrid.parameter`	the default is 2 that is for 'svmkrigesvmidw'; for 'svmsvmkrigesvmidw', it needs to be 3.
`lambda`	ranging from 0 to 2; the default is 1 for 'svmkrigesvmidw' and 'svmsvmkrigesvmidw'; and if it is < 1, more weight is placed on 'krige', otherwise more weight is placed on 'idw'; and if it is 0, 'idw' is not considered and the resultant methods is 'svmkrige' when the default 'hybrid.parameter' is used; and if it is 2, then the resultant method is 'svmidw' when the default 'hybrid.parameter' is used.
`...`	other arguments passed on to 'svm', 'krige' and 'gstat'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

David Meyer, Evgenia Dimitriadou, Kurt Hornik, Andreas Weingessel and Friedrich Leisch (2020). e1071: Misc Functions of the Department of Statistics, Probability Theory Group (Formerly: E1071), TU Wien. R package version 1.7-4. https://CRAN.R-project.org/package=e1071.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)

svmkrigeidwpred1 <- svmkrigeidwpred(formula.svm = model, longlat = longlat, trainxy = gravel,
predx = petrel.grid, y = y, longlatpredx = petrel.grid[, c(1:2)],
formula.krige = res1 ~ 1, vgm.args = "Sph", nmaxkrige = 12, idp = 2, nmaxidw = 12)

names(svmkrigeidwpred1)

# Back transform 'svmkrigeidwpred$predictions' to generate the final predictions
svmkrigeidw.predictions <- exp(svmkrigeidwpred1$predictions) - 1
range(svmkrigeidw.predictions)
```

svmkrigepred *Generate spatial predictions using the hybrid method of support vector machine ('svm') regression and 'krige' (svmkrige)*

Description

This function is for generating spatial predictions using the hybrid method of 'svm' and 'krige' (svmkrige).

Usage

```
svmkrigepred(
  formula.svm = NULL,
  longlat,
  trainxy,
  predx,
  y,
  longlatpredx,
  scale = TRUE,
  type = NULL,
  kernel = "radial",
  degree = 3,
  gamma = if (is.vector(trainxy)) 1 else 1/ncol(trainxy),
  coef0 = 0,
  cost = 1,
  nu = 0.5,
  tolerance = 0.001,
  epsilon = 0.1,
  transformation = "none",
  delta = 1,
  formula.krige = res1 ~ 1,
  vgm.args = c("Sph"),
  anis = c(0, 1),
  alpha = 0,
  block = 0,
  beta,
  nmaxkrige = 12,
  ...
)
```

Arguments

`formula.svm`	a formula defining the response variable and predictive variables for 'svm'.
`longlat`	a dataframe contains longitude and latitude of point samples.
`trainxy`	a dataframe contains longitude (long), latitude (lat), predictive variables and the response variable of point samples.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`y`	a vector of the response variable in the formula, that is, the left part of the formula.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted.
`scale`	A logical vector indicating the variables to be scaled (default: TRUE).
`type`	the default setting is 'NULL'. See '?svm' for various options.
`kernel`	the default setting is 'radial'. See '?svm' for other options.
`degree`	a parameter needed for kernel of type polynomial (default: 3).
`gamma`	a parameter needed for all 'kernels' except 'linear' (default: 1/(data dimension)).
`coef0`	a parameter needed for kernels of type 'polynomial' and 'sigmoid'(default: 0).
`cost`	cost of constraints violation (default: 1).
`nu`	a parameter needed for 'nu-classification', 'nu-regression', and 'one-classification' (default: 0.5).
`tolerance`	tolerance of termination criterion (default: 0.001).
`epsilon`	'epsilon' in the insensitive-loss function (default: 0.1). See '?svm' for details.
`transformation`	transform the residuals of 'svm' to normalise the data; can be "sqrt" for square root, "arcsine" for arcsine, "log" or "none" for non transformation. By default, "none" is used.
`delta`	numeric; to avoid log(0) in the log transformation. The default is 1.
`formula.krige`	formula defining the response vector and (possible) regressor. an object (i.e., 'variogram.formula') for 'variogram' or a formula for 'krige'. see 'variogram' and 'krige' in 'gstat' for details.
`vgm.args`	arguments for 'vgm', e.g. variogram model of response variable and anisotropy parameters. see 'vgm' in 'gstat' for details. By default, "Sph" is used.
`anis`	anisotropy parameters: see notes 'vgm' in 'gstat' for details.
`alpha`	direction in plane (x,y). see variogram in 'gstat' for details.
`block`	block size. see 'krige' in 'gstat' for details.
`beta`	for simple kriging. see 'krige' in 'gstat' for details.
`nmaxkrige`	for a local predicting: the number of nearest observations that should be used for a prediction or simulation, where nearest is defined in terms of the space of the spatial locations. By default, 12 observations are used.
`...`	other arguments passed on to 'svm' and 'krige'.

Value

A dataframe of longitude, latitude, and predictions.

Author(s)

Jin Li

References

Li, J., Potter, A., Huang, Z., and Heap, A. (2012). Predicting Seabed Sand Content across the Australian Margin Using Machine Learning and Geostatistical Methods, Geoscience Australia, Record 2012/48, 115pp.

Li, J., Heap, A., Potter, A., and Danilel, J.J. (2011). Predicting Seabed Mud Content across the Australian Margin II: Performance of Machine Learning Methods and Their Combination with Ordinary Kriging and Inverse Distance Squared, Geoscience Australia, Record 2011/07, 69pp.

David Meyer, Evgenia Dimitriadou, Kurt Hornik, Andreas Weingessel and Friedrich Leisch (2020). e1071: Misc Functions of the Department of Statistics, Probability Theory Group (Formerly: E1071), TU Wien. R package version 1.7-4. https://CRAN.R-project.org/package=e1071.

Pebesma, E.J., 2004. Multivariable geostatistics in S: the gstat package. Computers & Geosciences, 30: 683-691.

Examples

```
library(spm)

data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
longlat <- petrel[, c(1, 2)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)
y <- log(gravel[, 7] +1)

svmkrigepred1 <- svmkrigepred(formula.svm = model, longlat = longlat, trainxy =  gravel,
predx = petrel.grid, y = y, longlatpredx = petrel.grid[, c(1:2)],
transformation = "none", formula.krige = res1 ~ 1, vgm.args = "Sph", nmaxkrige = 12)

names(svmkrigepred1)

# Back transform 'svmkrigepred$predictions' to generate the final predictions
svmkrige.predictions <- exp(svmkrigepred1$predictions) - 1
range(svmkrige.predictions)
```

svmpred *Generate spatial predictions using support vector machine ('svm')*

Description

This function is for generating spatial predictions using 'svm' method in 'e1071' package.

Usage

```
svmpred(
  formula = NULL,
  trainxy,
  longlatpredx,
  predx,
  scale = TRUE,
  type = NULL,
  kernel = "radial",
  degree = 3,
  gamma = if (is.vector(trainxy)) 1 else 1/ncol(trainxy),
  coef0 = 0,
  cost = 1,
  nu = 0.5,
  tolerance = 0.001,
  epsilon = 0.1,
  ...
)
```

Arguments

`formula`	a formula defining the response variable and predictive variables.
`trainxy`	a dataframe contains predictive variables and the response variable of point samples. The location information, longitude (long), latitude (lat), need to be included in the 'trainx' for spatial predictive modeling, need to be named as 'long' and 'lat'.
`longlatpredx`	a dataframe contains longitude and latitude of point locations (i.e., the centers of grids) to be predicted, need to be named as 'long' and 'lat'.
`predx`	a dataframe or matrix contains columns of predictive variables for the grids to be predicted.
`scale`	A logical vector indicating the variables to be scaled (default: TRUE).
`type`	the default setting is 'NULL'. See '?svm' for various options.
`kernel`	the default setting is 'radial'. See '?svm' for other options.
`degree`	a parameter needed for kernel of type polynomial (default: 3).
`gamma`	a parameter needed for all 'kernels' except 'linear' (default: 1/(data dimension)).
`coef0`	a parameter needed for kernels of type 'polynomial' and 'sigmoid'(default: 0).

`cost`	cost of constraints violation (default: 1).
`nu`	a parameter needed for 'nu-classification', 'nu-regression', and 'one-classification' (default: 0.5).
`tolerance`	tolerance of termination criterion (default: 0.001).
`epsilon`	'epsilon' in the insensitive-loss function (default: 0.1). See '?svm' for details.
`...`	other arguments passed on to 'svm'.

Value

A dataframe of longitude, latitude and predictions.

Author(s)

Jin Li

References

David Meyer, Evgenia Dimitriadou, Kurt Hornik, Andreas Weingessel and Friedrich Leisch (2020). e1071: Misc Functions of the Department of Statistics, Probability Theory Group (Formerly: E1071), TU Wien. R package version 1.7-4. https://CRAN.R-project.org/package=e1071.

Examples

```
library(spm)
data(petrel)
data(petrel.grid)

gravel <- petrel[, c(1, 2, 6:9, 5)]
model <- log(gravel + 1) ~  lat +  bathy + I(long^3) + I(lat^2) + I(lat^3)

svmpred1 <- svmpred(formula = model, trainxy = gravel,
longlatpredx = petrel.grid[, c(1:2)], predx = petrel.grid)

names(svmpred1)

# Back transform 'svmpred1$pred.svm1' to generate the final predictions
svm.predictions <- exp(svmpred1$pred.svm1) - 1
range(svm.predictions)
```

`tpscv` *Cross validation, n-fold and leave-one-out for thin plate splines ('TPS')*

Description

This function is a cross validation function for 'Tps' method in 'fields' package.

Usage

```
tpscv(
  trainx,
  trainy,
  m = NULL,
  p = NULL,
  theta = 3,
  lambda = NULL,
  lon.lat = TRUE,
  validation = "CV",
  cv.fold = 10,
  predacc = "VEcv",
  ...
)
```

Arguments

`trainx`	a dataframe contains longitude (long), latitude (lat) and predictive variables of point samples. That is, they must be names as 'long' and 'lat'.
`trainy`	a vector of response, must have length equal to the number of rows in trainx.
`m`	A polynomial function of degree (m-1) will be included in the model as the drift (or spatial trend) component. Default is 'm = NULL' that is the value such that 2m-d is greater than zero where d is the dimension of x.
`p`	polynomial power for Wendland radial basis functions as in 'Tps'. 'p = NULL' that leads to a default value of 2 for spatial predictive modelling based on 'x' containing only the location information.
`theta`	the tapering range. 'theta = 3' degrees is a very generous taper range. For spatial predictive modeling the taper should be large enough to about 20 non zero nearest neighbors for every location.
`lambda`	smoothing parameter, the default is 'NULL'. See '?Tps' for further info.
`lon.lat`	if 'TRUE' locations are interpreted as longitude and latitude and great circle distance is used to find distances among locations.
`validation`	validation methods, include 'LOO': leave-one-out, and 'CV': cross-validation.
`cv.fold`	integer; number of folds in the cross-validation. if > 1, then apply n-fold cross validation; the default is 10, i.e., 10-fold cross validation that is recommended.
`predacc`	can be either "VEcv" for vecv or "ALL" for all measures in function pred.acc.
`...`	other arguments passed on to 'gstat'.

Value

A list with the following components: me, rme, mae, rmae, mse, rmse, rrmse, vecv and e1; or vecv only

Note

This function is largely based on 'krigecv' in this package and 'Tps' and 'fastTpsMLE' in 'fields' package.

Author(s)

Jin Li

References

Douglas Nychka and Reinhard Furrer and John Paige and Stephan Sain and Florian Gerber and Matthew Iverson, 2020. fields: Tools for Spatial Data, R package version 10.3 https://CRAN.R-project.org/package=fields.

Examples

```
library(fields)
library(spm)
data(petrel)

tpscv1 <- tpscv(petrel[, c(1,2)], petrel[, 5], cv.fold = 5, predacc = "VEcv")
tpscv1

tpscv1 <- tpscv(petrel[, c(1,2)], petrel[, 5], lambda = 0.9, cv.fold = 5, predacc = "VEcv")
tpscv1

tpscv1 <- tpscv(petrel[, c(1,2)], petrel[, 5], validation = "LOO", predacc = "VEcv")
tpscv1

set.seed(1234)
n <- 20 # number of iterations,60 to 100 is recommended.
VEcv <- NULL
for (i in 1:n) {
tpscv1 <- tpscv(petrel[, c(1,2)], petrel[, 5], cv.fold = 10,  lambda = 0.13, predacc = "VEcv")
VEcv [i] <- tpscv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for TPS", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)

n <- 20 # number of iterations,60 to 100 is recommended.
# set.seed(1234)
VEcv <- NULL
for (i in 1:n) {
set.seed(1234 + i) # set random seed for each iteration. You can remove
# this line and use above set.seed(1234) and see what you can get.
tpscv1 <- tpscv(petrel[, c(1,2)], petrel[, 5], predacc = "VEcv")
VEcv [i] <- tpscv1
}
plot(VEcv ~ c(1:n), xlab = "Iteration for TPS", ylab = "VEcv (%)")
points(cumsum(VEcv) / c(1:n) ~ c(1:n), col = 2)
abline(h = mean(VEcv), col = 'blue', lwd = 2)
```

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