Package ‘VSURF’

December 15, 2022

Type Package
Title Variable Selection Using Random Forests
Version 1.2.0
Date 2022-12-15
Depends R (>= 4.2.0)
Description Three steps variable selection procedure based on random forests. Initially developed to handle high dimensional data (for which number of variables largely exceeds number of observations), the package is very versatile and can treat most dimensions of data, for regression and supervised classification problems. First step is dedicated to eliminate irrelevant variables from the dataset. Second step aims to select all variables related to the response for interpretation purpose. Third step refines the selection by eliminating redundancy in the set of variables selected by the second step, for prediction purpose. Genuer, R. Poggi, J.-M. and Tuleau-Malot, C. (2015) <https://journal.r-project.org/archive/2015-2/genuer-poggi-tuleaumalot.pdf>.
License GPL (>= 2)
LazyData true
URL https://github.com/robingenuer/VSURF
BugReports https://github.com/robingenuer/VSURF/issues
Imports doParallel, foreach, parallel, randomForest, rpart
Suggests testthat, ranger, Rborist
RoxygenNote 7.1.2
NeedsCompilation no
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Repository CRAN
Date/Publication 2022-12-15 13:20:02 UTC
\textbf{R topics documented:}

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\textbf{plot.VSURF  \hspace{1cm} Plot of VSURF results}

\textbf{Description}

This function plots 4 graphs illustrating VSURF results.

\textbf{Usage}

\begin{verbatim}
## S3 method for class 'VSURF'
plot(
x,
  step = "all",
  var.names = FALSE,
  imp.mean = TRUE,
  imp.sd = TRUE,
  nvar.imp.mean = length(x$imp.mean.dec),
  nvar.imp.sd = length(x$imp.sd.dec),
  nvar.interp = length(x$varselect.thres),
  nvar.pred = length(x$varselect.pred),
  ...
)
\end{verbatim}

\begin{verbatim}
## S3 method for class 'VSURF_thres'
plot(
x,
  var.names = FALSE,
  imp.mean = TRUE,
  imp.sd = TRUE,
  nvar.imp.mean = length(x$imp.mean.dec),
  nvar.imp.sd = length(x$imp.sd.dec),
  ...
)
\end{verbatim}
## S3 method for class 'VSURF_interp'
plot(x, var.names = FALSE, nvar.interp = length(x$varselect.thres), ...)

## S3 method for class 'VSURF_pred'
plot(x, var.names = FALSE, nvar.pred = length(x$varselect.pred), ...)

### Arguments

- **x**
  An object of class VSURF, VSURF_thres, VSURF_interp or VSURF_pred, which is the result of the VSURF function (or resp. VSURF_thres, VSURF_interp or VSURF_pred).

- **step**
  A character string indicating which step must be plotted (default is "all"). Available choices are "thres", "interp", "pred".

- **var.names**
  If FALSE (default) xticks are the numbering given by the sorting of VI mean, if TRUE they are the variables names.

- **imp.mean**
  If TRUE (default) VI mean is plotted, if FALSE it is not.

- **imp.sd**
  If TRUE (default) VI standard deviation is plotted, if FALSE it is not.

- **nvar.imp.mean**
  The number of variables to be kept for the VI mean plot.

- **nvar.imp.sd**
  The number of variables to be kept for the VI standard deviation plot.

- **nvar.interp**
  The number of variables to be kept for the "interp" plot.

- **nvar.pred**
  The number of variables to be kept for the "pred" plot.

- **...**
  Arguments to be passed to par (they will affect all plots) or to others methods of plot.

### Details

The 2 graphs of the top row correspond to the "thresholding step" (and only these 2 graphs are plotted by the plot.VSURF_thres function). The top left graph plots the mean variable importance in decreasing order (black curve). The red horizontal line represent the value of the threshold. The top right graph plots the standard deviation of variable importance with variables ordered according to their mean variable importance in decreasing order (black curve). The green line represents the predictions given by a CART tree fitted to the black curve (the standard deviations). Finally, the dotted horizontal red line represents the minimum value of the CART predictions, which actually is the value of the threshold.

The bottom left graph corresponds to the "interpretation step" (and only this graph is plotted by the plot.VSURF_interp function). It plots the mean OOB error rate of embedded random forests models (from the one with only one variable as predictor, to the one with all variables kept after the "thresholding step"). The vertical red line indicates the retained model.

The bottom right graph corresponds to the "prediction step" (and only this graph is plotted by the plot.VSURF_pred function). It plots the mean OOB error rate of embedded random forests models (the difference, here, being that variables are added to the model in a step-wise manner). The retained model is the final one.
Author(s)
Robin Genuer, Jean-Michel Poggi and Christine Tuleau-Malot

References

See Also
VSURF, summary.VSURF

Examples

```r
## Not run:
data(iris)
iris.vsurf <- VSURF(iris[,1:4], iris[,5])
plot(iris.vsurf)
plot(iris.vsurf, var.names=TRUE)
plot(iris.vsurf, step="thres")

# A more interesting example with toys data (see \code{\link{toys}})
# (a few minutes to execute) and intermediate functions
data(toys)
toys.vsurf <- VSURF(toys$x, toys$y)
plot(toys.vsurf)
plot(toys.vsurf, nvar.imp.mean = 50, nvar.imp.sd = 50)
toys.thres <- VSURF_thres(toys$x, toys$y)
plot(toys.thres)
plot(toys.thres, nvar.imp.mean = 70, imp.sd = FALSE)
toys.interp <- VSURF_interp(toys$x, toys$y, vars = toys.thres$varselect.thres)
plot(toys.interp, var.names = TRUE)
toys.pred <- VSURF_pred(toys$x, toys$y, err.interp = toys.interp$err.interp,
                        varselect.interp = toys.interp$varselect.interp)
plot(toys.pred, var.names = TRUE)

## End(Not run)
```

PM10

Real-world data on PM10 pollution in Rouen area, France

Description
These data are TEOM (Tapered Element Oscillating Microbalance) PM10 concentrations from 2004 to 2006 (1096 days) measured by Air Normand, and the associated weather data provided by Meteo France, the French national meteorological service, using six different monitoring sites.
Usage

ail
gcm
gui
hri
jus
rep

Format

Each object is a data frame.
The description of the 18 variables is the following (note that for gcm station, only the pollutant SO2 is available in addition to PM10, and for ail station, there is no other pollutant in addition to PM10):

PM10  Daily mean concentration of PM10, in $\mu g/m^3$
NO, NO2, SO2  Daily mean concentration of NO, NO2, SO2, in $\mu g/m^3$
T.min, T.max, T.moy  Daily minimum, maximum and mean temperature, in degree Celsius
DV.maxv, DV.dom  Daily maximum speed and dominant wind direction, in degree (for wind direction, 0 degree corresponds to north)
VV.max, VV.moy  Daily maximum and mean wind speed, in m/s
PL.som  Daily rainfall, in mm
HR.min, HR.max, HR.moy  Daily minimum, maximum and mean relative humidity, in %
PA.moy  Daily mean air pressure, in hPa
GTrouen, GTle Havre  Daily temperature gradient, in degree Celsius

An object of class data.frame with 1096 rows and 15 columns.
An object of class data.frame with 1096 rows and 16 columns.
An object of class data.frame with 1096 rows and 18 columns.
An object of class data.frame with 1096 rows and 18 columns.
An object of class data.frame with 1096 rows and 18 columns.
An object of class data.frame with 1096 rows and 18 columns.

Details

Six different monitoring stations of the Rouen (Haute Normandie, France) area are considered. The urban station jus, the traffic station gui, the second most polluted in the region, and gcm which is located in an industrial area. In Le Havre, are considered the stations rep (the most polluted in the region) and hri located at the seaside. Lastly, the station ail near Dieppe, because it is rural and
predict.VSURF

Description

This function predicts new data with random forests, using variables selected by VSURF only.

Usage

```r
## S3 method for class 'VSURF'
predict(object, newdata, step = c("interp", "pred"), ...)
```

Arguments

- `object`: An object of class VSURF, which is the result of the VSURF function.
- `newdata`: A data frame or matrix containing new data. (Note: If not given, the out-of-bag predictions of the randomForest object is returned.)
- `step`: A character string indicating which variable set must be used to train the randomForest object (default is c("interp", "pred")). Available choices are "thres", "interp", "pred".
- `...`: Further parameters passed to randomForest or predict.randomForest functions (depending on their names).

Details

This method applies for a VSURF object. VSURF selects two sets of variables during its two last steps. For each set of variables, a random forest object is created, by running randomForest on training data using this set of variables only. Then the predict.randomForest function is used to predict new data.

Value

If only one step is indicated in `step`, a vector of predicted values.

If two or more steps are indicated in `step`, a data frame of predicted values (each column corresponding to a variable set).

Source

Author(s)
Robin Genuer, Jean-Michel Poggi and Christine Tuleau-Malot

References

See Also
VSURF

Examples

```r
## Not run:
data(iris)
iris.learn <- sample(1:nrow(iris), nrow(iris)/2)
iris.vsurf <- VSURF(iris[iris.learn, 1:4], iris[iris.learn, 5], ntree = 100, nfor.thres = 20, nfor.interp = 10, nfor.pred = 10)
iris.predictions <- predict(iris.vsurf, newdata = iris[-iris.learn, 1:4])
# A more interesting example with toys data (see \code{\link{toys}})
# (a few minutes to execute)
data(toys)
toys.learn <- 1:(nrow(toys$x) / 2)
toys.vsurf <- VSURF(toys$x[toys.learn, ], toys$y[toys.learn])
toys.predictions <- predict(toys.vsurf, newdata = toys$x[-toys.learn, ])
## End(Not run)
```

print.VSURF

Print of VSURF results

Description
This function display a small description of VSURF results

Usage

```r
## S3 method for class 'VSURF'
print(x, ...)  
```

Arguments

- `x` An object of class VSURF, which is the result of the VSURF function.
- `...` Not used.
Author(s)
Robin Genuer, Jean-Michel Poggi and Christine Tuleau-Malot

References

See Also
VSURF, plot.VSURF, summary.VSURF

Examples

```
## Not run:
data(iris)
iris.vsurf <- VSURF(iris[,1:4], iris[,5], ntree = 100, nfor.thres = 20,
                  nfor.interp = 10, nfor.pred = 10)
iris.vsurf
## End(Not run)
```

summary.VSURF Summary of VSURF results

Description
This function displays a summary of VSURF results

Usage
```
## S3 method for class 'VSURF'
summary(object, ...)
```

Arguments

<table>
<thead>
<tr>
<th>object</th>
<th>An object of class VSURF, which is the result of the VSURF function.</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>Not used.</td>
</tr>
</tbody>
</table>

Details
This function prints the total computation time of VSURF. It also gives the number of selected variables (and the computation time) at each step of VSURF. In addition, it gives the number of cores and the type of cluster if the parallel version of VSURF was used.
Author(s)
Robin Genuer, Jean-Michel Poggi and Christine Tuleau-Malot

References

See Also
VSURF, plot.VSURF

Examples
```r
## Not run:
data(iris)
iris.vsurf <- VSURF(iris[,1:4], iris[,5], ntree = 100, nfor.thres = 20,
nfor.interp = 10, nfor.pred = 10)
summary(iris.vsurf)
# A more interesting example with toys data (see \code{\link{toys}})
# (a few minutes to execute)
data(toys)
toys.vsurf <- VSURF(toys$x, toys$y)
summary(toys.vsurf)
## End(Not run)
```

toys

A simulated dataset called toys data

Description
toys is a simple simulated dataset of a binary classification problem, introduced by Weston et.al..

Format
The format is a list of 2 components:

x a dataframe containing input variables: with 100 obs. of 200 variables
y output variable: a factor with 2 levels "-1" and "1"
Details

It is an equiprobable two class problem, Y belongs to \{-1,1\}, with six true variables, the others being some noise. The simulation model is defined through the conditional distribution of the $X_i$ for $Y=y$:

- with probability 0.7, $X^j \sim N(yj,1)$ for $j=1,2,3$ and $X^j \sim N(0,1)$ for $j=4,5,6$;
- with probability 0.3, $X^j \sim N(0,1)$ for $j=1,2,3$ and $X^j \sim N(y(j-3),1)$ for $j=4,5,6$;
- the other variables are noise, $X^j \sim N(0,1)$ for $j=7,\ldots,p$.

After simulation, the obtained variables are finally standardized.

Source


Examples

data(toys)
toys.rf <- randomForest::randomForest(toys$x, toys$y)
toys.rf

## Not run:
# VSURF applied for toys data:
# (a few minutes to execute)
data(toys)
toys.vsurf <- VSURF(toys$x, toys$y)
toys.vsurf

## End(Not run)

---

tune

Tuning of the thresholding and interpretation steps of VSURF

Description

This function allows to tune the "thresholding" and "interpretation step" of VSURF, without rerunning all computations.

Usage

tune(x, ...)

## S3 method for class 'VSURF_thres'
tune(x, nmin = 1, ...)

## S3 method for class 'VSURF_interp'
tune(x, nsd = 1, ...)
tune

Arguments

- **x**: An object of class \texttt{VSURF\_thres} or \texttt{VSURF\_interp}, which is the result of the \texttt{VSURF\_thres} or \texttt{VSURF\_interp} function.
- **...**: Not used.
- **nmin**: Number of times the "minimum value" is multiplied to set threshold value. See details below.
- **nsd**: Number of times the standard deviation of the minimum value of \texttt{err\_interp} is multiplied. See details below.

Details

In \texttt{VSURF\_thres} function, the actual threshold is performed like this: only variables with a mean VI larger than \texttt{nmin * min\_thres} are kept. The function \texttt{tune.VSURF\_thres} allows you to change the value of \texttt{nmin} (which multiply the estimated threshold value \texttt{min\_thres}), without rerunning all computations. To get a softer threshold than default, choose a value of \texttt{nmin} less than 1, and to get a harder one, choose a value larger than 1.

In \texttt{VSURF\_interp} function, the smallest model (and hence its corresponding variables) having a mean OOB error rate less than \texttt{err\_min + nsd * sd\_min} is selected. The function \texttt{tune.VSURF\_interp} allows to change the value of \texttt{nsd} (which multiply the standard deviation of the minimum OOB error rate \texttt{sd\_min}), without rerunning all computations. To get a larger model than default, choose a value of \texttt{nsd} less than 1, and to get a smaller one, choose a value larger than 1.

Value

An object with the same structure than the original output (from \texttt{VSURF\_thres} or \texttt{VSURF\_interp}).

Author(s)

Robin Genuer, Jean-Michel Poggi and Christine Tuleau-Malot

References


See Also

\texttt{VSURF, VSURF\_thres, VSURF\_interp}

Examples

```r
## Not run:
data(iris)
iris.thres <- VSURF\_thres(iris[,1:4], iris[,5], ntree = 100, nfor.thres = 20)
iris.thres.tuned <- tune(iris.thres, nmin = 10)
```
```
iris.thres.tuned
iris.interp <- VSURF_interp(iris[,1:4], iris[,5], vars = iris.thres$varselect.thres,
                           nfor.interp = 10)
iris.interp.tuned <- tune(iris.interp, nsd = 10)
iris.interp.tuned
```

---

### VSURF

**Variable Selection Using Random Forests**

#### Description

Three steps variable selection procedure based on random forests for supervised classification and regression problems. First step ("thresholding step") is dedicated to eliminate irrelevant variables from the dataset. Second step ("interpretation step") aims to select all variables related to the response for interpretation purpose. Third step ("prediction step") refines the selection by eliminating redundancy in the set of variables selected by the second step, for prediction purpose.

#### Usage

```
VSURF(x, ...)
```

---

## Default S3 method:
VSURF(
  x,
  y,
  mtry = max(floor(ncol(x)/3), 1),
  ntree.thres = 500,
  nfor.thres = 20,
  nmin = 1,
  ntree.interp = 100,
  nfor.interp = 10,
  nsd = 1,
  ntree.pred = 100,
  nfor.pred = 10,
  nmj = 1,
  RFimplem = "randomForest",
  parallel = FALSE,
  ncores = detectCores() - 1,
  clusterType = "PSOCK",
  verbose = TRUE,
  ntree = 2000,
  ...
)
```

---

## S3 method for class 'formula'
VSURF(formula, data, ... , na.action = na.fail)
Arguments

x, formula
A data frame or a matrix of predictors, the columns represent the variables. Or a formula describing the model to be fitted.

... others parameters to be passed on to the randomForest function (see ?randomForest for further information).

y A response vector (must be a factor for classification problems and numeric for regression ones).

mtry Number of variables randomly sampled as candidates at each split. Standard parameter of randomForest.

ntree.thres Number of trees of each forest grown for "thresholding step" (first of the three steps).

nfor.thres Number of forests grown for "thresholding step".

nmin Number of times the "minimum value" is multiplied to set threshold value. See details below.

ntree.interp Number of trees of each forest grown for "interpretation step" (second of the three steps).

nfor.interp Number of forests grown for "interpretation step".

nsd Number of times the standard deviation of the minimum value of err.interp is multiplied. See details below.

ntree.pred Number of trees of each forest grown for "prediction step" (last of the three steps).

nfor.pred Number of forests grown for "prediction step".

nmj Number of times the mean jump is multiplied. See details below.

RFimplem Choice of the random forests implementation to use: "randomForest" (default), "ranger" or "Rborist" (not that if "Rborist" is chosen, "randomForest" will still be used for the first step VSURF_thres). If a vector of length 3 is given, each coordinate is passed to each intermediate function: VSURF_thres, VSURF_interp, VSURF_pred, in this order.

parallel A logical indicating if you want VSURF to run in parallel on multiple cores (default to FALSE). If a vector of length 3 is given, each coordinate is passed to each intermediate function: VSURF_thres, VSURF_interp, VSURF_pred, in this order.

ncores Number of cores to use. Default is set to the number of cores detected by R minus 1.

clusterType Type of the multiple cores cluster used to run VSURF in parallel. Must be chosen among "PSOCK" (default: SOCKET cluster available locally on all OS), "FORK" (local too, only available for Linux and Mac OS), "MPI" (can be used on a remote cluster, which needs snow and Rmpi packages installed), "ranger" and "Rborist" for internal parallelizations of those packages (not that if "Rborist" is chosen, "SOCKET" will still be used for the first step VSURF_thres). If a vector of length 2 is given, each coordinate is passed to each intermediate function: VSURF_thres, VSURF_interp, in this order.
verbose A logical indicating if information about method's progress (included progress bars for each step) must be printed (default to TRUE). Adds a small extra overload.

ntree (deprecated) Number of trees in each forest grown for "thresholding step".

data a data frame containing the variables in the model.

na.action A function to specify the action to be taken if NAs are found. (NOTE: If given, this argument must be named, and as randomForest it is only used with the formula-type call.)

Details

- First step ("thresholding step"): first, nfor.thres random forests are computed using the function randomForest with arguments importance=TRUE, and our choice of default values for ntree and mtry (which are higher than default in randomForest to get a more stable variable importance measure). Then variables are sorted according to their mean variable importance (VI), in decreasing order. This order is kept all along the procedure. Next, a threshold is computed: min.thres, the minimum predicted value of a pruned CART tree fitted to the curve of the standard deviations of VI. Finally, the actual "thresholding step" is performed: only variables with a mean VI larger than nmin * min.thres are kept.

- Second step ("interpretation step"): the variables selected by the first step are considered. nfor.interp embedded random forests models are grown, starting with the random forest build with only the most important variable and ending with all variables selected in the first step. Then, err.min the minimum mean out-of-bag (OOB) error of these models and its associated standard deviation sd.min are computed. Finally, the smallest model (and hence its corresponding variables) having a mean OOB error less than err.min + nsd * sd.min is selected.

Note that for this step (and the next one), the mtry parameter of randomForest is set to its default value (see randomForest) if nvm, the number of variables in the model, is not greater than the number of observations, while it is set to nvm/3 otherwise. This is to ensure quality of OOB error estimations along embedded RF models.

- Third step ("prediction step"): the starting point is the same than in the second step. However, now the variables are added to the model in a stepwise manner. mean.jump, the mean jump value is calculated using variables that have been left out by the second step, and is set as the mean absolute difference between mean OOB errors of one model and its first following model. Hence a variable is included in the model if the mean OOB error decrease is larger than nmj * mean.jump.

As for interpretation step, the mtry parameter of randomForest is set to its default value if nvm, the number of variables in the model, is not greater than the number of observations, while it is set to nvm/3 otherwise.

VSURF is able to run using multiple cores in parallel (see parallel, clusterType and ncores arguments).

Value

An object of class VSURF, which is a list with the following components:
varselect.thres
    A vector of indexes of variables selected after "thresholding step", sorted according to their mean VI, in decreasing order.

varselect.interp
    A vector of indexes of variables selected after "interpretation step".

varselect.pred
    A vector of indexes of variables selected after "prediction step".

nums.varselect
    A vector of the 3 numbers of variables selected resp. by "thresholding step", "interpretation step" and "prediction step".

imp.varselect.thres
    A vector of importance of the varselect.thres variables.

min.thres
    The minimum predicted value of a pruned CART tree fitted to the curve of the standard deviations of VI.

imp.mean.dec
    A vector of the variables importance means (over nfor.thres runs), in decreasing order.

imp.mean.dec.ind
    The ordering index vector associated to the sorting of variables importance means.

imp.sd.dec
    A vector of standard deviations of all variables importance. The order is given by imp.mean.dec.ind.

mean.perf
    Mean OOB error rate, obtained by a random forests build on all variables.

pred.pruned.tree
    Predictions of the CART tree fitted to the curve of the standard deviations of VI.

err.interp
    A vector of the mean OOB error rates of the embedded random forests models build during the "interpretation step".

sd.min
    The standard deviation of OOB error rates associated to the random forests model attaining the minimum mean OOB error rate during the "interpretation step".

err.pred
    A vector of the mean OOB error rates of the random forests models build during the "prediction step".

mean.jump
    The mean jump value computed during the "prediction step".

rmin,nsd,nmj
    Corresponding parameters values.

overall.time
    Overall computation time.

comput.times
    A list of the 3 computation times respectively associated with the 3 steps: "thresholding", "interpretation" and "prediction".

RFimplem
    The RF implementation used to run VSURF, among "randomForest" (default), "ranger" and "Rborist" or a vector of length 3 with those.

ncores
    The number of cores used to run VSURF in parallel (NULL if VSURF did not run in parallel).

clusterType
    The type of the cluster used to run VSURF in parallel (NULL if VSURF did not run in parallel).

call
    The original call to VSURF.

terms
    Terms associated to the formula (only if formula-type call was used).

na.action
    Method used to deal with missing values (only if formula-type call was used).
Author(s)
Robin Genuer, Jean-Michel Poggi and Christine Tuleau-Malot

References

See Also
plot.VSURF, summary.VSURF, VSURF_thres, VSURF_interp, VSURF_pred, tune

Examples

data(iris)
iris.vsurf <- VSURF(iris[,1:4], iris[,5])
iris.vsurf

## Not run:
# A more interesting example with toys data (see \code{\link{toys}})
# (a few minutes to execute)
data(toys)
toys.vsurf <- VSURF(toys$x, toys$y)
toys.vsurf

# VSURF run on 2 cores in parallel (using a SOCKET cluster):
data(toys)
toys.vsurf.parallel <- VSURF(toys$x, toys$y, parallel = TRUE, ncores = 2)

## End(Not run)

---

VSURF_interp  Interpretation step of VSURF

Description
Interpretation step aims to select all variables related to the response for interpretation purpose. This is the second step of the VSURF function. It is designed to be executed after the thresholding step VSURF_thres.
Usage

`VSURF_interp(x, ...)`

## Default S3 method:
`VSURF_interp(
  x,
  y,
  vars,
  ntree.interp = 100,
  nfor.interp = 25,
  nsd = 1,
  RFimplem = "randomForest",
  parallel = FALSE,
  ncores = detectCores() - 1,
  clusterType = "PSOCK",
  verbose = TRUE,
  ntree = NULL,
  ...
)

## S3 method for class 'formula'
`VSURF_interp(formula, data, ..., na.action = na.fail)`

Arguments

x, formula  A data frame or a matrix of predictors, the columns represent the variables. Or a formula describing the model to be fitted.

...  others parameters to be passed on to the `randomForest` function (see `?randomForest` for further information).

y  A response vector (must be a factor for classification problems and numeric for regression ones).

vars  A vector of variable indices. Typically, indices of variables selected by thresholding step (see value `varselect.thres` of `VSURF_thres` function).

ntree.interp  Number of trees of each forest grown.

nfor.interp  Number of forests grown.

nsd  Number of times the standard deviation of the minimum value of `err.interp` is multiplied. See details below.

RFimplem  Choice of the random forests implementation to use: "randomForest" (default), "ranger" or "Rborist" (not that if "Rborist" is chosen, "randoForest" will still be used for the first step `VSURF_thres`). If a vector of length 3 is given, each coordinate is passed to each intermediate function: `VSURF_thres`, `VSURF_interp`, `VSURF_pred`, in this order.

parallel  A logical indicating if you want VSURF to run in parallel on multiple cores (default to FALSE). If a vector of length 3 is given, each coordinate is passed to each intermediate function: `VSURF_thres`, `VSURF_interp`, `VSURF_pred`, in this order.
ncores  Number of cores to use. Default is set to the number of cores detected by R minus 1.

clusterType  Type of the multiple cores cluster used to run VSURF in parallel. Must be chosen among "PSOCK" (default: SOCKET cluster available locally on all OS), "FORK" (local too, only available for Linux and Mac OS), "MPI" (can be used on a remote cluster, which needs snow and Rmpi packages installed), "ranger" and "Rborist" for internal parallelizations of those packages (not that if "Rborist" is chosen, "SOCKET" will still be used for the first step VSURF_thres). If a vector of length 2 is given, each coordinate is passed to each intermediate function: VSURF_thres, VSURF_interp, in this order.

verbose  A logical indicating if information about method's progress (included progress bars for each step) must be printed (default to TRUE). Adds a small extra overload.

ntree  (deprecated) Number of trees in each forest grown for "thresholding step".

data  a data frame containing the variables in the model.

na.action  A function to specify the action to be taken if NAs are found. (NOTE: If given, this argument must be named, and as randomForest it is only used with the formula-type call.)

Details

nfor_interp embedded random forests models are grown, starting with the random forest build with only the most important variable and ending with all variables. Then, err.min the minimum mean out-of-bag (OOB) error rate of these models and its associated standard deviation sd.min are computed. Finally, the smallest model (and hence its corresponding variables) having a mean OOB error less than err.min + nsd * sd.min is selected.

Note that, the mtry parameter of randomForest is set to its default value (see randomForest) if nvm, the number of variables in the model, is not greater than the number of observations, while it is set to nvm/3 otherwise. This is to ensure quality of OOB error estimations along embedded RF models.

Value

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

vselect_interp  A vector of indices of selected variables.

err_interp  A vector of the mean OOB error rates of the embedded random forests models.

sd.min  The standard deviation of OOB error rates associated to the random forests model attaining the minimum mean OOB error rate.

num.vselect_interp  The number of selected variables.

vselect_thres  A vector of indexes of variables selected after "thresholding step", sorted according to their mean VI, in decreasing order.

nsd  Value of the parameter in the call.
VSURF_interp

comput.time  Computation time.
RFimplem   The RF implementation used to run VSURF_interp.
ncores     The number of cores used to run VSURF_interp in parallel (NULL if VSURF_interp did not run in parallel).
clusterType The type of the cluster used to run VSURF_interp in parallel (NULL if VSURF_interp did not run in parallel).
call       The original call to VSURF.
terms      Terms associated to the formula (only if formula-type call was used).

Author(s)
Robin Genuer, Jean-Michel Poggi and Christine Tuleau-Malot

References

See Also
VSURF, tune

Examples

data(iris)
iris.thres <- VSURF_thres(iris[,1:4], iris[,5])
iris.interp <- VSURF_interp(iris[,1:4], iris[,5],
   vars = iris.thres$varselect.thres)
iris.interp

## Not run:
# A more interesting example with toys data (see \code{\link{toys}})
# (a few minutes to execute)
data(toys)
toys.thres <- VSURF_thres(toys$x, toys$y)
toys.interp <- VSURF_interp(toys$x, toys$y,
   vars = toys.thres$varselect.thres)
toys.interp
## End(Not run)
Prediction step of VSURF

Description

Prediction step refines the selection of interpretation step VSURF_interp by eliminating redundancy in the set of variables selected, for prediction purpose. This is the third step of the VSURF function.

Usage

```
VSURF_pred(x, ...)
```

## Default S3 method:
```
VSURF_pred(
  x,
  y,
  err.interp,
  varselect.interp,
  ntree.pred = 100,
  nfor.pred = 10,
  nmj = 1,
  RFimplem = "randomForest",
  parallel = FALSE,
  ncores = detectCores() - 1,
  verbose = TRUE,
  ntree = NULL,
  ...
)
```

## S3 method for class 'formula'
```
VSURF_pred(formula, data, ..., na.action = na.fail)
```

Arguments

- **x**, **formula**
  A data frame or a matrix of predictors, the columns represent the variables. Or a formula describing the model to be fitted.
- **...**
  Others parameters to be passed on to the randomForest function (see ?randomForest for further information).
- **y**
  A response vector (must be a factor for classification problems and numeric for regression ones).
- **err.interp**
  A vector of the mean OOB error rates of the embedded random forests models build during interpretation step (value err.interp of function VSURF_interp).
- **varselect.interp**
  A vector of indices of variables selected after interpretation step.
- **ntree.pred**
  Number of trees of each forest grown.
VSURF_pred

nfor.pred  Number of forests grown.
nmj  Number of times the mean jump is multiplied. See details below.
RFimplem  Choice of the random forests implementation to use: "randomForest" (default), "ranger" or "Rborist" (not that if "Rborist" is chosen, "randomForest" will still be used for the first step VSURF_thres). If a vector of length 3 is given, each coordinate is passed to each intermediate function: VSURF_thres, VSURF_interp, VSURF_pred, in this order.
parallel  A logical indicating if you want VSURF to run in parallel on multiple cores (default to FALSE). If a vector of length 3 is given, each coordinate is passed to each intermediate function: VSURF_thres, VSURF_interp, VSURF_pred, in this order.
ncores  Number of cores to use. Default is set to the number of cores detected by R minus 1.
verbose  A logical indicating if information about method's progress (included progress bars for each step) must be printed (default to TRUE). Adds a small extra overload.
ntree  (deprecated) Number of trees in each forest grown for "thresholding step".
data  a data frame containing the variables in the model.
na.action  A function to specify the action to be taken if NAs are found. (NOTE: If given, this argument must be named, and as randomForest it is only used with the formula-type call.)

Details

nfor.pred embedded random forests models are grown, starting with the random forest build with only the most important variable. Variables are added to the model in a stepwise manner. The mean jump value mean.jump is calculated using variables that have been left out by interpretation step, and is set as the mean absolute difference between mean OOB errors of one model and its first following model. Hence a variable is included in the model if the mean OOB error decrease is larger than nmj * mean.jump.

Note that, the mtry parameter of randomForest is set to its default value (see randomForest) if nvm, the number of variables in the model, is not greater than the number of observations, while it is set to nvm/3 otherwise. This is to ensure quality of OOB error estimations along embedded RF models.

Value

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

varselect.pred  A vector of indices of variables selected after "prediction step".
err.pred  A vector of the mean OOB error rates of the random forests models build during the "prediction step".
mean.jump  The mean jump value computed during the "prediction step".
num.varselect.pred  The number of selected variables.
Value of the parameter in the call.

Computation time.

The RF implementation used to run \texttt{VSURF\_pred}.

The original call to \texttt{VSURF}.

Terms associated to the formula (only if formula-type call was used).

Author(s)

Robin Genuer, Jean-Michel Poggi and Christine Tuleau-Malot

References


See Also

\texttt{VSURF}

Examples

data(iris)
iris.thres <- VSURF\_thres(iris[,1:4], iris[,5])
iris.interp <- VSURF\_interp(iris[,1:4], iris[,5],
  vars = iris.thres$varselect.thres)
iris.pred <- VSURF\_pred(iris[,1:4], iris[,5],
  err.interp = iris.interp$err.interp,
  varselect.interp = iris.interp$varselect.interp)
iris.pred

## Not run:
# A more interesting example with toys data (see \code{\link{toys}})
# (a few minutes to execute)
data(toys)
toys.thres <- VSURF\_thres(toys$x, toys$y)
toys.interp <- VSURF\_interp(toys$x, toys$y,
  vars = toys.thres$varselect.thres)
toys.pred <- VSURF\_pred(toys$x, toys$y, err.interp = toys.interp$err.interp,
  varselect.interp = toys.interp$varselect.interp)
toys.pred
## End(Not run)
Thresholding step of VSURF

Description
Thresholding step is dedicated to roughly eliminate irrelevant variables at the dataset. This is the first
step of the VSURF function. For refined variable selection, see VSURF other steps: VSURF_interp
and VSURF_pred.

Usage

VSURF_thres(x, ...)

## Default S3 method:
VSURF_thres(  
x,  
y,  
mtry = max(floor(ncol(x)/3), 1),  
ntree.thres = 500,  
nfor.thres = 20,  
nmin = 1,  
RFimplem = "randomForest",  
parallel = FALSE,  
clusterType = "PSOCK",  
ncores = parallel::detectCores() - 1,  
verbose = TRUE,  
ntree = NULL,  
...  
)

## S3 method for class 'formula'
VSURF_thres(formula, data, ..., na.action = na.fail)

Arguments

x, formula A data frame or a matrix of predictors, the columns represent the variables. Or
a formula describing the model to be fitted.

... others parameters to be passed on to the randomForest function (see ?randomForest for further information).

y A response vector (must be a factor for classification problems and numeric for
regression ones).

mtry Number of variables randomly sampled as candidates at each split. Standard
parameter of randomForest.

ntree.thres Number of trees of each forest grown.
nfor.thres Number of forests grown.
VSURF_thres

**nmin**
Number of times the "minimum value" is multiplied to set threshold value. See details below.

**RFimplem**
Choice of the random forests implementation to use: "randomForest" (default), "ranger" or "Rborist" (not that if "Rborist" is chosen, "randomForest" will still be used for the first step VSURF_thres). If a vector of length 3 is given, each coordinate is passed to each intermediate function: VSURF_thres, VSURF_interp, VSURF_pred, in this order.

**parallel**
A logical indicating if you want VSURF to run in parallel on multiple cores (default to FALSE). If a vector of length 3 is given, each coordinate is passed to each intermediate function: VSURF_thres, VSURF_interp, VSURF_pred, in this order.

**clusterType**
Type of the multiple cores cluster used to run VSURF in parallel. Must be chosen among "PSOCK" (default: SOCKET cluster available locally on all OS), "FORK" (local too, only available for Linux and Mac OS), "MPI" (can be used on a remote cluster, which needs snow and Rmpi packages installed), "ranger" and "Rborist" for internal parallelizations of those packages (not that if "Rborist" is chosen, "SOCKET" will still be used for the first step VSURF_thres). If a vector of length 2 is given, each coordinate is passed to each intermediate function: VSURF_thres, VSURF_interp, in this order.

**ncores**
Number of cores to use. Default is set to the number of cores detected by R minus 1.

**verbose**
A logical indicating if information about method's progress (included progress bars for each step) must be printed (default to TRUE). Adds a small extra overload.

**ntree**
(deprecated) Number of trees in each forest grown for "thresholding step".

**data**
a data frame containing the variables in the model.

**na.action**
A function to specify the action to be taken if NAs are found. (NOTE: If given, this argument must be named, and as randomForest it is only used with the formula-type call.)

**Details**
First, nfor.thres random forests are computed using the function randomForest with arguments importance=TRUE, and our choice of default values for ntree and mtry (which are higher than default in randomForest to get a more stable variable importance measure). Then variables are sorted according to their mean variable importance (VI), in decreasing order. This order is kept all along the procedure. Next, a threshold is computed: min.thres, the minimum predicted value of a pruned CART tree fitted to the curve of the standard deviations of VI. Finally, the actual thresholding is performed: only variables with a mean VI larger than nmin * min.thres are kept.

**Value**
An object of class VSURF_thres, which is a list with the following components:

**varselect.thres**
A vector of indices of selected variables, sorted according to their mean VI, in decreasing order.
imp.varselect.thres
A vector of importance of the varselect.thres variables.

min.thres
The minimum predicted value of a pruned CART tree fitted to the curve of the standard deviations of VI.

num.varselect.thres
The number of selected variables.

imp.mean.dec
A vector of the variables importance means (over nfor.thres runs), in decreasing order.

imp.mean.dec.ind
The ordering index vector associated to the sorting of variables importance means.

imp.sd.dec
A vector of standard deviations of all variables importance. The order is given by imp.mean.dec.ind.

mean.perf
The mean OOB error rate, obtained by a random forests build with all variables.

pred.pruned.tree
The predictions of the CART tree fitted to the curve of the standard deviations of VI.

nmin
Value of the parameter in the call.

comput.time
Computation time.

RFimplem
The RF implementation used to run VSURF_thres.

ncores
The number of cores used to run VSURF_thres in parallel (NULL if VSURF_thres did not run in parallel).

clusterType
The type of the cluster used to run VSURF_thres in parallel (NULL if VSURF_thres did not run in parallel).

call
The original call to VSURF.

terms
Terms associated to the formula (only if formula-type call was used).

Author(s)
Robin Genuer, Jean-Michel Poggi and Christine Tuleau-Malot

References

See Also
VSURF, tune
Examples

data(iris)
iris.thres <- VSURF_thres(iris[,1:4], iris[,5])
iris.thres

## Not run:
# A more interesting example with toys data (see \code{\link{toys}})
# (a few minutes to execute)
data(toys)
toys.thres <- VSURF_thres(toys$x, toys$y)
toys.thres
## End(Not run)
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