

Package ‘GMDH2’

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Type Package

Title Binary Classification via GMDH-Type Neural Network Algorithm

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MASS, plotly, magrittr, xtable

Suggests mlbench

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Description Performs binary classification via Group Method of Data Handling (GMDH) - type neural network algorithm. There exist two main algorithms available in GMDH() and dceGMDH() functions. GMDH() performs classification via GMDH algorithm for a binary response and returns important variables. dceGMDH() performs classification via diverse classifiers ensemble based on GMDH (dce-GMDH) algorithm. Also, the package produces a well-formatted table of descriptives for a binary response. Moreover, it produces confusion matrix and related statistics and scatter plot (2D and 3D) with classification labels of binary classes to assess the prediction performance. All 'GMDH2' functions are designed for a binary response. See Dag O. and Yozgatligil C. (2016, ISSN:2073-4859) and Kondo T. and Ueno J. (2016, ISSN:1349-4198) for the details of GMDH algorithms.

License GPL (>= 2)

NeedsCompilation no

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GMDH2-package	<i>Binary Classification via GMDH-Type Neural Network Algorithm</i>
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Description

Performs binary classification via Group Method of Data Handling (GMDH) - type neural network algorithm. There exist two main algorithms available in GMDH() and dceGMDH() functions. GMDH() performs classification via GMDH algorithm for a binary response and returns important variables. dceGMDH() performs classification via diverse classifiers ensemble based on GMDH (dce-GMDH) algorithm. Also, the package produces a well-formatted table of descriptives for a binary response. Moreover, it produces confusion matrix and related statistics and scatter plot (2D and 3D) with classification labels of binary classes to assess the prediction performance. All 'GMDH2' functions are designed for a binary response. See Dag O. and Yozgatligil C. (2016, ISSN:2073-4859) and Kondo T. and Ueno J. (2016, ISSN:1349-4198) for the details of GMDH algorithms.

Details

Package: GMDH
 Type: Package
 License: GPL (>=2)

confMat	<i>Confusion Matrix</i>
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Description

confMat constructs a 2×2 confusion matrix and returns some statistics related to confusion matrix.

Usage

```
confMat(data, ...)
```

```
## Default S3 method:
confMat(data, reference, positive = NULL, verbose = TRUE, ...)

## S3 method for class 'table'
confMat(data, positive = NULL, verbose = TRUE, ...)
```

Arguments

data a factor of predicted classes (for the default method) or an object of class `table`.
... option to be passed to `table`. Note: do not include `reference` here.
reference a factor of classes to be used as the true results.
positive an optional character string for the factor level that corresponds to a "positive" result.
verbose a logical for printing output to R console.

Details

The `confMat` function requires that the factors have exactly the same levels. The function constructs 2×2 confusion matrix and calculates accuracy, no information rate (NIR), unweighted Kappa statistic, Matthews correlation coefficient, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), prevalence, balanced accuracy, youden index, detection rate, detection prevalence, precision, recall and F1 measure.

Suppose a 2×2 table with notation

	Reference	
Predicted	Event	No Event
Event	TP	FP
No Event	FN	TN

TP is the number of true positives, FP is the number of false positives, FN is the number of false negatives and TN is the number of true negatives.

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN}$$

$$NIR = \max(Prevalence, 1 - Prevalence)$$

$$Kappa = \frac{Accuracy - \frac{(TP+FP)(TP+FN)+(FN+TN)(FP+TN)}{(TP+FP+FN+TN)^2}}{1 - \frac{(TP+FP)(TP+FN)+(FN+TN)(FP+TN)}{(TP+FP+FN+TN)^2}}$$

$$MCC = \frac{TP \times TN - FN \times FP}{\sqrt{(TP + FP) \times (FN + TN) \times (TP + FN) \times (FP + TN)}}$$

$$Sensitivity = \frac{TP}{TP + FN}$$

$$\textit{Specificity} = \frac{TN}{TN + FP}$$

$$\textit{PPV} = \frac{TP}{TP + FP}$$

$$\textit{NPV} = \frac{TN}{TN + FN}$$

$$\textit{Prevalence} = \frac{TP + FN}{TP + FP + FN + TN}$$

$$\textit{Balanced accuracy} = \frac{\textit{Sensitivity} + \textit{Specificity}}{2}$$

$$\textit{Youden index} = \textit{Sensitivity} + \textit{Specificity} - 1$$

$$\textit{Detection rate} = \frac{TP}{TP + FP + FN + TN}$$

$$\textit{Detection prevalence} = \frac{TP + FP}{TP + FP + FN + TN}$$

$$\textit{Precision} = \frac{TP}{TP + FP}$$

$$\textit{Recall} = \frac{TP}{TP + FN}$$

$$\textit{F1} = \frac{2}{\frac{1}{\textit{Recall}} + \frac{1}{\textit{Precision}}}$$

Value

Returns a list containing following elements:

table	confusion matrix
accuracy	accuracy
NIR	no information rate
kappa	unweighted kappa
MCC	Matthews correlation coefficient
sensitivity	sensitivity
specificity	specificity
PPV	positive predictive value
NPV	negative predictive value
prevalence	prevalence
baccuracy	balanced accuracy
youden	youden index
detectRate	detection rate
detectPrev	detection prevalence
precision	precision
recall	recall
F1	F1 measure
all	returns a matrix containing all statistics

Note

If the factors, reference and data, have the same levels, but in the incorrect order, the confMat will reorder data with the order of reference.

Author(s)

Osman Dag

See Also

[confusionMatrix](#)

Examples

```
library(GMDH2)

library(mlbench)
data(BreastCancer)

data <- BreastCancer

# to obtain complete observations
completeObs <- complete.cases(data)
data <- data[completeObs,]

x <- data.matrix(data[,2:10])
y <- data[,11]

seed <- 11111
set.seed(seed)

nobs <- length(y)

# to split train and test sets
train.indices <- sort(sample(1:nobs, round(nobs*0.8,0)))
test.indices <- (1:nobs)[-train.indices]

x.train <- x[train.indices,]
y.train <- y[train.indices]

x.test <- x[test.indices,]
y.test <- y[test.indices]

set.seed(seed)

# to construct model via dce-GMDH algorithm
model <- dceGMDH(x.train, y.train)

# to obtain predicted classes for train set
y.train_pred <- predict(model, x.train, type = "class")
```

```
# to obtain confusion matrix and some statistics for train set
confMat(y.train_pred, y.train, positive = "malignant")

# to obtain predicted classes for test set
y.test_pred <- predict(model, x.test, type = "class")

# to obtain confusion matrix and some statistics for test set
confMat(y.test_pred, y.test, positive = "malignant")

# to obtain statistics from table
result <- table(y.test_pred, y.test)
confMat(result, positive = "malignant")
```

cplot2d

2D Scatter Plot with Classification Labels

Description

cplot2d produces two dimensional scatter plot with classification labels of binary classes.

Usage

```
cplot2d(x1, x2, ypred, yobs, colors = c("red", "blue"), symbols = c("circle", "o"),
        size = 10, xlab = NULL, ylab = NULL, title = NULL)
```

Arguments

x1	the horizontal coordinate of points in the plot.
x2	the vertical coordinate of points in the plot.
ypred	a factor of the predicted binary response variable.
yobs	a factor of the observed binary response variable.
colors	a vector of two colors specifying the levels of the observed binary response variable.
symbols	a vector of two symbols specifying the levels of the predicted binary response variable.
size	the size of symbols.
xlab	a label for the x axis, defaults to a description of x1.
ylab	a label for the y axis, defaults to a description of x2.
title	a main title of the plot.

Details

Symbols indicate the observed classes of binary response. Colors show TRUE or FALSE classification of the observations.

Value

An object with class "plotly" and "htmlwidget".

Author(s)

Osman Dag

See Also

[plot_ly](#)

Examples

```
library(GMDH2)

library(mlbench)
data(BreastCancer)

data <- BreastCancer

# to obtain complete observations
completeObs <- complete.cases(data)
data <- data[completeObs,]

x <- data.matrix(data[,2:10])
y <- data[,11]

seed <- 11111
set.seed(seed)

nobs <- length(y)

# to split train and test sets
train.indices <- sort(sample(1:nobs, round(nobs*0.8,0)))
test.indices <- (1:nobs)[-train.indices]

x.train <- x[train.indices,]
y.train <- y[train.indices]

x.test <- x[test.indices,]
y.test <- y[test.indices]

set.seed(seed)

# to construct model via dce-GMDH algorithm
model <- dceGMDH(x.train, y.train)

# to obtain predicted classes for train set
y.train_pred <- predict(model, x.train, type = "class")
```

```
# to obtain confusion matrix and some statistics for train set
confMat(y.train_pred, y.train, positive = "malignant")

# to obtain predicted classes for test set
y.test_pred <- predict(model, x.test, type = "class")

# to obtain confusion matrix and some statistics for test set
confMat(y.test_pred, y.test, positive = "malignant")

# to produce 2D scatter plot with classification labels for test set
cplot2d(x.test[,1], x.test[,6], y.test_pred, y.test, symbols = c("x", "o"))
cplot2d(x.test[,1], x.test[,6], y.test_pred, y.test, colors = c("red", "black"))
```

cplot3d

3D Scatter Plot with Classification Labels

Description

cplot3d produces three dimensional scatter plot with classification labels of binary classes.

Usage

```
cplot3d(x1, x2, x3, ypred, yobs, colors = c("red", "blue"),
        symbols = c("circle", "o"), size = 10, xlab = NULL, ylab = NULL, zlab = NULL,
        title = NULL)
```

Arguments

x1	the x coordinate of points in the plot.
x2	the y coordinate of points in the plot.
x3	the z coordinate of points in the plot.
ypred	a factor of the predicted binary response variable.
yobs	a factor of the observed binary response variable.
colors	a vector of two colors specifying the levels of the observed binary response variable.
symbols	a vector of two symbols specifying the levels of the predicted binary response variable.
size	the size of symbols.
xlab	a label for the x axis, defaults to a description of x1.
ylab	a label for the y axis, defaults to a description of x2.
zlab	a label for the z axis, defaults to a description of x3.
title	a main title of the plot.

Details

Symbols indicate the observed classes of binary response. Colors show TRUE or FALSE classification of the observations.

Value

An object with class "plotly" and "htmlwidget".

Author(s)

Osman Dag

See Also

[plot_ly](#)

Examples

```
library(GMDH2)

library(mlbench)
data(BreastCancer)

data <- BreastCancer

# to obtain complete observations
completeObs <- complete.cases(data)
data <- data[completeObs,]

x <- data.matrix(data[,2:10])
y <- data[,11]

seed <- 11111
set.seed(seed)

nobs <- length(y)

# to split train and test sets
train.indices <- sort(sample(1:nobs, round(nobs*0.8,0)))
test.indices <- (1:nobs)[-train.indices]

x.train <- x[train.indices,]
y.train <- y[train.indices]

x.test <- x[test.indices,]
y.test <- y[test.indices]

set.seed(seed)

# to construct model via dce-GMDH algorithm
```

```

model <- dceGMDH(x.train, y.train)

# to obtain predicted classes for train set
y.train_pred <- predict(model, x.train, type = "class")

# to obtain confusion matrix and some statistics for train set
confMat(y.train_pred, y.train, positive = "malignant")

# to obtain predicted classes for test set
y.test_pred <- predict(model, x.test, type = "class")

# to obtain confusion matrix and some statistics for test set
confMat(y.test_pred, y.test, positive = "malignant")

# to produce 3D scatter plot with classification labels for test set
cplot3d(x.test[,1], x.test[,6], x.test[,3], y.test_pred, y.test,
colors = c("red", "black"))

```

dceGMDH

*Diverse Classifiers Ensemble Based on GMDH-Type Neural Network
Algorithm for Binary Classification*

Description

dceGMDH makes a binary classification via diverse classifiers ensemble Based on GMDH-Type Neural Network (dce-GMDH) Algorithm.

Usage

```

dceGMDH(x, y, rate = 0.75, alpha = 0.6, maxlayers = 10, maxneurons = 15,
exCriterion = "MSE", verbose = TRUE, svm_options, randomForest_options,
naiveBayes_options, cv.glmnet_options, nnet_options, ...)

```

Arguments

x	a nxp matrix, n is the number of observations and p is the number of variables.
y	a factor of binary response variable.
rate	the rate of observations to be included in model construction. The rest of the observations is used for neuron selection. Defaults rate = 0.75.
alpha	the selection pressure in a layer. Defaults alpha = 0.6.
maxlayers	the number of maximum layers. Defaults maxlayers = 10.
maxneurons	the number of maximum neurons selected in each layer. Defaults maxneurons = 15.
exCriterion	a character string to select an external criteria. "MSE": Mean Square Error, "MAE": Mean Absolute Error. Default is set to "MSE".

verbose	a logical for printing summary output to R console.
svm_options	a list for options of <code>svm</code> .
randomForest_options	a list for options of <code>randomForest</code> .
naiveBayes_options	a list for options of <code>naiveBayes</code> .
cv.glmnet_options	a list for options of <code>cv.glmnet</code> .
nnet_options	a list for options of <code>nnet</code> .
...	not used currently.

Value

A list with class "dceGMDH" and "GMDHplot" containing the following components:

architecture	all objects stored in construction process of network
nlayer	the number of layers
neurons	the number of neurons in layers
sneurons	the number of selected neurons in layers
structure	the summary structure of the process
levels	the levels of binary response
base_perf	the performances of the classifiers on validation set at base training
base_models	the constructed base classifiers models
train.indices	the indices of training set
valid.indices	the indices of validation set
classifiers	the names of assembled classifiers
plot_list	the list of objects to be used in <code>plot.GMDHplot</code>

Author(s)

Osman Dag, Erdem Karabulut, Reha Alpar

References

- Dag, O., Yozgatligil, C. (2016). GMDH: An R Package for Short Term Forecasting via GMDH-Type Neural Network Algorithms. *The R Journal*, **8:1**, 379-386.
- Ivakhnenko, A. G. (1966). Group Method of Data Handling - A Rival of the Method of Stochastic Approximation. *Soviet Automatic Control*, **13**, 43-71.
- Kondo, T., Ueno, J. (2006). Revised GMDH-Type Neural Network Algorithm With A Feedback Loop Identifying Sigmoid Function Neural Network. *International Journal of Innovative Computing, Information and Control*, **2:5**, 985-996.

Examples

```
library(GMDH2)

library(mlbench)
data(BreastCancer)

data <- BreastCancer

# to obtain complete observations
completeObs <- complete.cases(data)
data <- data[completeObs,]

x <- data.matrix(data[,2:10])
y <- data[,11]

seed <- 11111
set.seed(seed)

nobs <- length(y)

# to split train and test sets
train.indices <- sort(sample(1:nobs, round(nobs*0.8,0)))
test.indices <- (1:nobs)[-train.indices]

x.train <- x[train.indices,]
y.train <- y[train.indices]

x.test <- x[test.indices,]
y.test <- y[test.indices]

set.seed(seed)

# to construct model via dce-GMDH algorithm
model <- dceGMDH(x.train, y.train)

# to obtain predicted classes for train set
predict(model, x.train)

# to obtain predicted classes for test set
predict(model, x.test)
```

Description

GMDH makes classification and feature selection via GMDH-type neural network algorithm.

Usage

```
GMDH(x, y, rate = 0.75, alpha = 0.6, maxlayers = 10, maxneurons = 15,
     exCriterion = "MSE", verbose = TRUE, ...)
```

Arguments

x	a nxp matrix, n is the number of observations and p is the number of variables.
y	a factor of binary response variable.
rate	the rate of observations to be included in model construction. The rest of the observations is used for neuron selection. Defaults rate = 0.75.
alpha	the selection pressure in a layer. Defaults alpha = 0.6.
maxlayers	the number of maximum layers. Defaults maxlayers = 10.
maxneurons	the number of maximum neurons selected in each layer. Defaults maxneurons = 15.
exCriterion	a character string to select an external criteria. "MSE": Mean Square Error, "MAE": Mean Absolute Error. Default is set to "MSE".
verbose	a logical for printing summary output to R console.
...	not used currently.

Value

A list with class "GMDH" and "GMDHplot" containing the following components:

architecture	all objects stored in construction process of network
nlayer	the number of layers
neurons	the number of neurons in layers
sneurons	the number of selected neurons in layers
structure	the summary structure of the process
levels	the levels of binary response
train.indices	the indices of training set
valid.indices	the indices of validation set
features	the names of variables used in GMDH algorithm
pfeatures	the column number of variables used in GMDH algorithm
nvar	the number of variables in the data set
plot_list	the list of objects to be used in plot.GMDHplot

Author(s)

Osman Dag, Erdem Karabulut, Reha Alpar

References

- Dag, O., Yozgatligil, C. (2016). GMDH: An R Package for Short Term Forecasting via GMDH-Type Neural Network Algorithms. *The R Journal*, **8:1**, 379-386.
- Ivakhnenko, A. G. (1966). Group Method of Data Handling - A Rival of the Method of Stochastic Approximation. *Soviet Automatic Control*, **13**, 43-71.
- Kondo, T., Ueno, J. (2006). Revised GMDH-Type Neural Network Algorithm With A Feedback Loop Identifying Sigmoid Function Neural Network. *International Journal of Innovative Computing, Information and Control*, **2:5**, 985-996.

Examples

```
library(GMDH2)

library(mlbench)
data(BreastCancer)

data <- BreastCancer

# to obtain complete observations
completeObs <- complete.cases(data)
data <- data[completeObs,]

x <- data.matrix(data[,2:10])
y <- data[,11]

seed <- 11111
set.seed(seed)

nobs <- length(y)

# to split train and test sets
train.indices <- sort(sample(1:nobs, round(nobs*0.8,0)))
test.indices <- (1:nobs)[-train.indices]

x.train <- x[train.indices,]
y.train <- y[train.indices]

x.test <- x[test.indices,]
y.test <- y[test.indices]

set.seed(seed)

# to construct model via GMDH algorithm
model <- GMDH(x.train, y.train)
```

plot.GMDHplot	<i>Plotting Using GMDH and dce-GMDH Algorithm for Binary Classification</i>
---------------	---

Description

This function plots minimum specified external criterion across layers based upon a model trained by GMDH or dceGMDH. This is plotted for validation set.

Usage

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

Arguments

x	an object of class created by GMDH or dceGMDH.
...	currently not used.

Author(s)

Osman Dag

See Also

[GMDH](#), [dceGMDH](#)

Examples

```
library(GMDH2)  
  
library(mlbench)  
data(BreastCancer)  
  
data <- BreastCancer  
  
# to obtain complete observations  
completeObs <- complete.cases(data)  
data <- data[completeObs,]  
  
x <- data.matrix(data[,2:10])  
y <- data[,11]  
  
seed <- 11111  
set.seed(seed)  
  
nobs <- length(y)
```

```

# to split train and test sets
train.indices <- sort(sample(1:nobs, round(nobs*0.8,0)))
test.indices <- (1:nobs)[-train.indices]

x.train <- x[train.indices,]
y.train <- y[train.indices]

x.test <- x[test.indices,]
y.test <- y[test.indices]

set.seed(seed)

# to construct model via GMDH algorithm
model <- GMDH(x.train, y.train)
plot(model)

# to construct model via dce-GMDH algorithm
model2 <- dceGMDH(x.train, y.train)
plot(model2)

```

predict.dceGMDH

Predicting Using dce-GMDH Algorithm for Binary Classification

Description

This function predicts values based upon a model trained by dceGMDH.

Usage

```

## S3 method for class 'dceGMDH'
predict(object, x, type = "class", ...)

```

Arguments

object	an object of class "dceGMDH", created by dceGMDH.
x	a matrix containing the new input data.
type	a character string to return predicted output. If type = "class", the function returns the predicted classes. If type = "probability", it returns the predicted probabilities. Default is set to "class".
...	currently not used.

Value

A vector of predicted values of corresponding classes depending on type specified.

Author(s)

Osman Dag, Erdem Karabulut, Reha Alpar

See Also

[dceGMDH](#)

Examples

```
library(GMDH2)

library(mlbench)
data(BreastCancer)

data <- BreastCancer

# to obtain complete observations
completeObs <- complete.cases(data)
data <- data[completeObs,]

x <- data.matrix(data[,2:10])
y <- data[,11]

seed <- 11111
set.seed(seed)

nobs <- length(y)

# to split train and test sets
train.indices <- sort(sample(1:nobs, round(nobs*0.8,0)))
test.indices <- (1:nobs)[-train.indices]

x.train <- x[train.indices,]
y.train <- y[train.indices]

x.test <- x[test.indices,]
y.test <- y[test.indices]

set.seed(seed)

# to construct model via dce-GMDH algorithm
model <- dceGMDH(x.train, y.train)

# to obtain predicted classes for train set
predict(model, x.train, type = "class")
# to obtain predicted probabilities for train set
predict(model, x.train, type = "probability")

# to obtain predicted classes for test set
```

```
predict(model, x.test, type = "class")
# to obtain predicted probabilities for test set
predict(model, x.test, type = "probability")
```

predict.GMDH

Predicting Using GMDH Algorithm for Binary Classification

Description

This function predicts values based upon a model trained by GMDH.

Usage

```
## S3 method for class 'GMDH'
predict(object, x, type = "class", ...)
```

Arguments

object	an object of class "GMDH", created by GMDH.
x	a matrix containing the new input data.
type	a character string to return predicted output. If type = "class", the function returns the predicted classes. If type = "probability", it returns the predicted probabilities. Default is set to "class".
...	currently not used.

Value

A vector of predicted values of corresponding classes depending on type specified.

Author(s)

Osman Dag, Erdem Karabulut, Reha Alpar

See Also

[GMDH](#)

Examples

```
library(GMDH2)

library(mlbench)
data(BreastCancer)

data <- BreastCancer
```

```

# to obtain complete observations
completeObs <- complete.cases(data)
data <- data[completeObs,]

x <- data.matrix(data[,2:10])
y <- data[,11]

seed <- 11111
set.seed(seed)

nobs <- length(y)

# to split train and test sets
train.indices <- sort(sample(1:nobs, round(nobs*0.8,0)))
test.indices <- (1:nobs)[-train.indices]

x.train <- x[train.indices,]
y.train <- y[train.indices]

x.test <- x[test.indices,]
y.test <- y[test.indices]

set.seed(seed)

# to construct model via GMDH algorithm
model <- GMDH(x.train, y.train)

# to obtain predicted classes for train set
predict(model, x.train, type = "class")
# to obtain predicted probabilities for train set
predict(model, x.train, type = "probability")

# to obtain predicted classes for test set
predict(model, x.test, type = "class")
# to obtain predicted probabilities for test set
predict(model, x.test, type = "probability")

```

Table

Table for Simple Descriptive Statistics

Description

Table produces a table for simple descriptive statistics for a binary response.

Usage

```

Table(x, y, option = "min-max", percentages = "column", ndigits = c(2,1),
      output = "R")

```

Arguments

x	a data frame including all variables.
y	a factor of binary response variable.
option	an option to return "min-max" or "Q1-Q3". Default is set to "min-max".
percentages	a character string to select the desired percentages. To use column or row percentages, percentages should be set to "column" or "row", respectively. The percentages argument is set to "total" to obtain total percentages. Default is set to "column".
ndigits	a vector of two numbers. The first one is used to specify the number of digit for numeric/integer variables. The second one specifies the number of digits for percentages of factor/ordered variables. Default is set to ndigits = c(2,1).
output	a character string to specify the format of descriptive statistics. If output = "LaTeX", it returns the table as latex format. If output = "HTML", it produces the table as html format. If output = "R", it returns the table in R console.

Author(s)

Osman Dag

Examples

```
library(GMDH2)

library(mlbench)
data(BreastCancer)

data <- BreastCancer

# to obtain complete observations
completeObs <- complete.cases(data)
data <- data[completeObs,]

x <- data[,2:10]
y <- data[,11]

Table(x, y)
```

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