Package ‘IDmining’

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**Type** Package

**Title** Intrinsic Dimension for Data Mining

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**Description** Contains techniques for mining large high-dimensional data sets by using the concept of Intrinsic Dimension (ID). Here the ID is not necessarily integer. It is extended to fractal dimensions. And the Morisita estimator is used for the ID estimation, but other tools are included as well.

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IDmining-package

Contains techniques for mining large high-dimensional data sets by using the concept of Intrinsic Dimension (ID). Here the ID is not necessarily integer. It is extended to fractal dimensions. And the Morisita estimator is used for the ID estimation, but other tools are included as well.

Author(s)

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References


See Also

Useful links:

- https://www.sites.google.com/site/jeangolayresearch/
Butterfly Data Set Generator

Description
Generates a random simulation of the butterfly data set with a given number of points.

Usage
`butterfly(N=10000)`

Arguments
- `N` The number of points to be generated (by default: `N = 10000`).

Value
A $N \times 9$ data frame. The first eight columns are the input variables, and the last one is the output (or target) variable $Y$.

Author(s)
Jean Golay <Jean.Golay@unil.ch>

References

Examples
```r
bf <- butterfly(1000)

## Not run:
require(colorRamps)
require(rgl)

c <- cut(bf$Y,breaks=64)
cols <- matlab.like(64)[as.numeric(c)]

plot3d(bf$X1,bf$X2,bf$Y,col=cols,radius=0.10,type="s",
       xlab="",ylab="",zlab="",box=F)
axes3d(lwd=3,cex.axis=3)
grid3d(c("x","y","z"),col="black",lwd=1)

## End(Not run)
```
The Multipoint Morisita Index in 1, 2 or Higher Dimensions

Description

Computes the ln values of the multipoint Morisita index in 1, 2 or higher dimensional spaces.

Usage

logMINDEX(x, scaleQ=1:5, mMin=2, mMax=2)

Arguments

X A $N \times E$ matrix, data.frame or data.table where $N$ is the number of data points and $E$ is the number of variables (or features). Each variable is rescaled to the $[0,1]$ interval by the function.

scaleQ Either a single value or a vector. It contains the value(s) of $\ell^{-1}$ chosen by the user (by default: scaleQ = 1:5).

mMin The minimum value of $m$ (by default: mMin = 2).

mMax The maximum value of $m$ (by default: mMax = 2).

Details

1. $\ell$ is the edge length of the grid cells (or quadrats). Since the variables (and consequently the grid) are rescaled to the $[0,1]$ interval, $\ell$ is equal to 1 for a grid consisting of only one cell.

2. $\ell^{-1}$ is the number of grid cells (or quadrats) along each axis of the Euclidean space in which the data points are embedded.

3. $\ell^{-1}$ is equal to $Q^{(1/E)}$ where $Q$ is the number of grid cells and $E$ is the number of variables (or features).

4. $\ell^{-1}$ is directly related to $\delta$ (see References).

5. $\delta$ is the diagonal length of the grid cells.

Value

A data.frame containing the ln value of the m-Morisita index for each value of ln($\delta$) and $m$. Notice also that the values of ln($\delta$) are provided with regard to the $[0,1]$ interval.

Author(s)

Jean Golay <Jean.Golay@unil.ch>

References

Examples

sim_dat <- SwissRoll(1000)

m <- 2
scaleQ <- 1:15  # It starts with a grid of 1*E cell (or quadrat).
# It ends with a grid of 15*E cells (or quadrats).
lnmmI <- logMINDEX(sim_dat, scaleQ, m, m)

dev.new(width=5, height=4)
plot(exp(lnmmI[,1]),exp(lnmmI[,2]),pch=19,col="black",ylab="",yaxt="n")
title(xlab = expression(delta), cex.lab = 1.5,line = 2.5)
title(ylab = expression(I[2,"delta]], cex.lab = 1.5,line = 2.5)

dev.new(width=5, height=4)
plot(lnmmI[,1],lnmmI[,2],pch=19,col="black",ylab="",yaxt="n")
title(xlab = expression(paste("log","delta,")), cex.lab = 1.5,line = 2.5)
title(ylab = expression(paste("log","I[2,"delta,"]]", cex.lab = 1.5,line = 2.5)

MBFR

Morisita-Based Filter for Regression Problems

Description

Executes the MBFR algorithm for supervised feature selection.

Usage

MBFR(XY, scaleQ, m=2, C=NULL)

Arguments

XY  A N x E matrix, data.frame or data.table where N is the number of data points, E is the number of variables (i.e. the input variables also called "features" + the output variable). The last column contains the values of the output variable. And each variable (input + output) is rescaled to the [0, 1] interval by the function.

scaleQ  A vector containing the values of \( \ell^{-1} \) chosen by the user (see Details).

m  The value of the parameter m (by default: m=2).

C  The number of steps of the SFS procedure (by default: C = E-1).

Details

1. \( \ell \) is the edge length of the grid cells (or quadrats). Since the data (and consequently the grid) are rescaled to the [0, 1] interval, \( \ell \) is equal to 1 for a grid consisting of only one cell.

2. \( \ell^{-1} \) is the number of grid cells (or quadrats) along each axis of the Euclidean space in which the data points are embedded.
3. $\ell^{-1}$ is equal to $Q^{1/E}$ where $Q$ is the number of grid cells and $E$ is the number of variables (or features).
4. $\ell^{-1}$ is directly related to $\delta$ (see References).
5. $\delta$ is the diagonal length of the grid cells.
6. The values of $\ell^{-1}$ in ScaleQ must be chosen according to the linear part of the log-log plot relating the log values of the multipoint Morisita index to the log values of $\delta$ (or, equivalently, to the log values of $\ell^{-1}$) (see logMINDEX).

**Value**

A list of five elements:

1. a vector containing the identifier numbers of the original features in the order they are selected through the Sequential Forward Selection (SFS) search procedure.
2. the names of the corresponding features.
3. the corresponding values of Diss.
4. the ID estimate of the output variable.
5. a $C \times 3$ matrix containing: (column 1) the ID estimates of the subsets retained by the SFS procedure with the target variable; (column 2) the ID estimates of the subsets retained by the SFS procedure without the output variable; (column 3) the values of Diss of the subsets retained by the SFS procedure.

**Author(s)**

Jean Golay <Jean.Golay@unil.ch>

**References**


**Examples**

```r
## Not run:
bf <- Butterfly(10000)
fly_select <- MBFR(bf, 5:25)
var_order <- fly_select[[2]]
var_perf <- fly_select[[3]]

dev.new(width=5, height=4)
plot(var_perf,type="b",pch=16,lwd=2,xaxt="n",xlab="",ylab="",
     ylim=c(0,1),col="red",panel.first=grid(lwd=1.5))
axis(1,1:length(var_order),labels=var_order)
mtext(1, text = "Added Features (from left to right)", line = 2.5,cex=1)
```
**MBFR_parallel**

mtext(2, text = "Estimated Dissimilarity", line = 2.5, cex=1)

## End(Not run)

---

**MBFR_parallel**  
*Morisita-Based Filter for Regression Problems (Parallel)*

### Description

Executes the MBFR algorithm on a chosen number of workers (CPU parallel computing).

### Usage

```
MBFR_parallel(XY, scaleQ, m=2, C=NULL, ncores=4)
```

### Arguments

- **XY**  
  A \( N \times E \) matrix, `data.frame` or `data.table` where \( N \) is the number of data points, \( E \) is the number of variables (i.e. the input variables also called "features" + the output variable). The last column contains the values of the output variable. And each variable (input + output) is rescaled to the \([0, 1]\) interval by the function.

- **scaleQ**  
  A vector containing the values of \( l^{-1} \) chosen by the user (see Details).

- **m**  
  The value of the parameter \( m \) (by default: \( m=2 \)).

- **C**  
  The number of steps of the SFS procedure (by default: \( C = E-1 \)).

- **ncores**  
  Number of workers (by default: \( ncores = 4 \)).

### Details

1. \( l \) is the edge length of the grid cells (or quadrats). Since the data (and consequently the grid) are rescaled to the \([0, 1]\) interval, \( l \) is equal to 1 for a grid consisting of only one cell.

2. \( l^{-1} \) is the number of grid cells (or quadrats) along each axis of the Euclidean space in which the data points are embedded.

3. \( l^{-1} \) is equal to \( Q^{(1/E)} \) where \( Q \) is the number of grid cells and \( E \) is the number of variables (or features).

4. \( l^{-1} \) is directly related to \( \delta \) (see References).

5. \( \delta \) is the diagonal length of the grid cells.

6. The values of \( l^{-1} \) in `ScaleQ` must be chosen according to the linear part of the log-log plot relating the log values of the multipoint Morisita index to the log values of \( \delta \) (or, equivalently, to the log values of \( l^{-1} \)) (see `logMINDEX`).
**Value**

A list of five elements:

1. a vector containing the identifier numbers of the original features in the order they are selected through the Sequential Forward Selection (SFS) search procedure.
2. the names of the corresponding features.
3. the corresponding values of $Diss$.
4. the ID estimate of the output variable.
5. a $C \times 3$ matrix containing: (column 1) the ID estimates of the subsets retained by the SFS procedure with the target variable; (column 2) the ID estimates of the subsets retained by the SFS procedure without the output variable; (column 3) the values of $Diss$ of the subsets retained by the SFS procedure.

**Author(s)**

Jean Golay <Jean.Golay@unil.ch>

**References**


**Examples**

```r
## Not run:
bf <- Butterfly(10000)
fly_select <- MBFR_parallel(bf, 5:25, ncores=2)
var_order <- fly_select[[2]]
var_perf <- fly_select[[3]]

dev.new(width=5, height=4)
plot(var_perf,type="b",pch=16,lwd=2,xaxt="n",xlab="",ylab="",
     ylim=c(0,1),col="red",panel.first={grid(lwd=1.5)})
axis(1,1:length(var_order),labels=var_order)
mtext(1, text = "Added Features (from left to right)", line = 2.5,cex=1)
mtext(2, text = "Estimated Dissimilarity", line = 2.5,cex=1)

bf_large <- Butterfly(10^5)
system.time(MBFR(bf_large, 5:25))
system.time(MBFR_parallel(bf_large, 5:25))

## End(Not run)
```
Morisita-Based Filter for Redundancy Minimization

Description

Executes the MBRM algorithm for unsupervised feature selection.

Usage

```r
MBRM(x, scaleQ, m=2, C=NULL, ID_tot=NULL)
```

Arguments

- `x`: A `N x E` matrix, `data.frame` or `data.table` where `N` is the number of data points and `E` is the number of variables (or features). Each variable is rescaled to the `[0, 1]` interval by the function.
- `scaleQ`: A vector containing the values of $\ell^{-1}$ chosen by the user (see Details).
- `m`: The value of the parameter `m` (by default: `m=2`).
- `C`: The number of steps of the SFS procedure (by default: `C=E`).
- `ID_tot`: The value of the full data ID if it is known a priori (by default: the value of `ID_tot` is estimated using the Morisita estimator of ID within the function).

Details

1. $\ell$ is the edge length of the grid cells (or quadrats). Since the the variables (and consequently the grid) are rescaled to the `[0, 1]` interval, $\ell$ is equal to 1 for a grid consisting of only one cell.
2. $\ell^{-1}$ is the number of grid cells (or quadrats) along each axis of the Euclidean space in which the data points are embedded.
3. $\ell^{-1}$ is equal to $Q^{(1/E)}$ where $Q$ is the number of grid cells and $E$ is the number of variables (or features).
4. $\ell^{-1}$ is directly related to $\delta$ (see References).
5. $\delta$ is the diagonal length of the grid cells.
6. The values of $\ell^{-1}$ in `ScaleQ` must be chosen according to the linear part of the log-log plot relating the log values of the multipoint Morisita index to the log values of $\delta$ (or, equivalently, to the log values of $\ell^{-1}$) (see `logMINDEX`).

Value

A list of four elements:

1. a vector containing the identifier numbers of the original features in the order they are selected through the Sequential Forward Selection (SFS) search procedure.
2. the names of the corresponding features.
3. the corresponding ID estimates.
4. the ID estimate of the full data set.
Author(s)
Jean Golay <Jean.Golay@unil.ch>

References

Examples

```r
bf <- Butterfly(10000)
bf_select <- MBRM(bf[, -9], 5:25)
var_order <- bf_select[[2]]
var_perf <- bf_select[[3]]

dev.new(width=5, height=4)
plot(var_perf, type="b", pch=16, lwd=2, xaxt="n", xlab="", ylab="",
    col="red", ylim=c(0, max(var_perf)), panel.first=(grid(lwd=1.5))),
    axis(1, 1:length(var_order), labels=var_order)
mtext(1, text="Added Features (from left to right)", line=2.5, cex=1)
mtext(2, text="Estimated ID", line=2.5, cex=1)
```

MBRM_parallel

Morisita-Based Filter for Redundancy Minimization (Parallel)

Description
Executes the MBRM algorithm for unsupervised feature selection (CPU parallel computing).

Usage

```r
MBRM_parallel(X, scaleQ, m=2, C=NULL, ID_tot=NULL, ncores=4)
```

Arguments

- **X**: A $N \times E$ matrix, data.frame or data.table where $N$ is the number of data points and $E$ is the number of variables (or features). Each variable is rescaled to the $[0,1]$ interval by the function.

- **scaleQ**: A vector containing the values of $\ell^{-1}$ chosen by the user (see Details).

- **m**: The value of the parameter $m$ (by default: $m=2$).

- **C**: The number of steps of the SFS procedure (by default: $C = E$).

- **ID_tot**: The value of the full data ID if it is known a priori (by default: the value of ID_tot is estimated using the Morisita estimator of ID within the function).

- **ncores**: Number of workers (by default: ncores = 4).
**Details**

1. $\ell$ is the edge length of the grid cells (or quadrats). Since the variables (and consequently the grid) are rescaled to the $[0, 1]$ interval, $\ell$ is equal to 1 for a grid consisting of only one cell.

2. $\ell^{-1}$ is the number of grid cells (or quadrats) along each axis of the Euclidean space in which the data points are embedded.

3. $\ell^{-1}$ is equal to $Q^{1/E}$ where $Q$ is the number of grid cells and $E$ is the number of variables (or features).

4. $\ell^{-1}$ is directly related to $\delta$ (see References).

5. $\delta$ is the diagonal length of the grid cells.

6. The values of $\ell^{-1}$ in ScaleQ must be chosen according to the linear part of the log-log plot relating the log values of the multipoint Morisita index to the log values of $\delta$ (or, equivalently, to the log values of $\ell^{-1}$) (see logMINDEX).

**Value**

A list of four elements:

1. a vector containing the identifier numbers of the original features in the order they are selected through the Sequential Forward Selection (SFS) search procedure.

2. the names of the corresponding features.

3. the corresponding ID estimates.

4. the ID estimate of the full data set.

**Author(s)**

Jean Golay <Jean.Golay@unil.ch>

**References**


**Examples**

```r
bf <- Butterfly(10000)

bf_select <- MBRM_parallel(bf[, -9], 5:25, ncores=2)
var_order <- bf_select[[2]]
var_perf <- bf_select[[3]]

dev.new(width=5, height=4)
plot(var_perf, type="b", pch=16, lwd=2, xaxt="n", xlab="", ylab="", col="red", ylim=c(0, max(var_perf)), panel.first=(grid(lwd=1.5)))
axis(1,1:length(var_order), labels=var_order)
mtext(1, text="Added Features (from left to right)", line=2.5, cex=1)
mtext(2, text="Estimated ID", line=2.5, cex=1)

## Not run:
```
bf_large <- Butterfly(10*5)
system.time(MBRM(bf_large[,9], 5:25))
system.time(MBRM_parallel(bf_large[,9], 5:25))

## End(Not run)

---

### Description

Computes the multipoint Morisita index for spatial patterns (i.e. 2-dimensional patterns).

### Usage

```r
MINDEX_SP(X, scaleQ=1:5, mMin=2, mMax=5, Wlim_x=NULL, Wlim_y=NULL)
```

### Arguments

- **X**: A \( N \times 2 \) matrix, data.frame or data.table containing the \( X \) and \( Y \) coordinates of \( N \) data points. The \( X \) coordinates must be given in the first column and the \( Y \) coordinates in the second column.
- **scaleQ**: Either a single value or a vector. It contains the value(s) of \( Q^{(1/2)} \) chosen by the user where \( Q \) is the number of cells (or quadrats) of the 2D grid (by default: \( scaleQ = 1:5 \)).
- **mMin**: The minimum value of \( m \) (by default: \( mMin = 2 \)).
- **mMax**: The maximum value of \( m \) (by default: \( mMax = 5 \)).
- **Wlim_x**: A vector controlling the spatial extent of the 2D grid along the \( X \) axis. It consists of two real values, i.e. \( Wlim_x <- c(a,b) \) where \( b > a \) (by default: \( Wlim_x <- c(min(X[,1]),max(X[,1])) \)).
- **Wlim_y**: A vector controlling the spatial extent of the 2D grid along the \( Y \) axis. It consists of two real values, i.e. \( Wlim_y <- c(a,b) \) where \( b > a \) (by default: \( Wlim_y <- c(min(X[,2]),max(X[,2])) \)).

### Details

1. \( Q^{(1/2)} \) is the number of grid cells (or quadrats) along each of the two axes.
2. \( Q^{(1/2)} \) is directly related to \( \delta \) (see References).
3. \( \delta \) is the diagonal length of the grid cells.

### Value

A data.frame containing the value of the m-Morisita index for each value of \( \delta \) and \( m \).

### Author(s)

Jean Golay <Jean.Golay@unil.ch>
**References**


**Examples**

```r
sim_dat <- SwissRoll(1000)

m <- 2
scaleq <- 1:15  # It starts with a grid of 1^2 cell (or quadrat).
                # It ends with a grid of 15^2 cells (or quadrats).
mMl <- MINDEX_SP(sim_dat[,c(1,2)], scaleQ, m, 5)
plot(mMl[,1],mMl[,2],pch=19,col="black",ylab="",xlab="")
title(xlab=expression(deltaLcexNlab\ (Nula}),cex.lab=1.5,line=2.5)
title(ylab=expression(l2+\delta}),cex.lab=1.5,line=2.5)

## Not run:
require(colorRamps)
colfunc <- colorRampPalette(c("blue","red"))
color <- colfunc(4)
dev.new(width=5,height=4)
plot(mMl[5:15,1],mMl[5:15,2],pch=19,col=color[1],ylab="",xlab="",
     ylim=c(1,max(mMl[,5])))
title(xlab=expression(delta),cex.lab=1.5,line=2.5)
title(ylab=expression(l2+\delta}),cex.lab=1.5,line=2.5)
for(i in 3:5){
  points(mMl[5:15,1],mMl[5:15,i],pch=19,col=color[i-1])
}
legend.text<-c("m=2","m=3","m=4","m=5")
legend.pch=col=19,19,19,19)
legend.lwd=c(NA,NA,NA,NA)
legend.col=c(color[1],color[2],color[3],color[4])
legend("topright",legend.text,pch=legend.pch,lwd=legend.lwd,
       col=legend.col,ncol=7,text.col="black",cex=0.9,box.lwd=1,bg="white")

xlim_l <- c(-5,5)  # By default, the spatial extent of the grid is set so
ylim_l <- c(-6,6)  # that it is the same as the spatial extent of the data.
xlim_s <- c(-0.6,0.2)  # But it can be modified to cover either a larger (l)
ylim_s <- c(-1,0.5)  # or a smaller (s) study area (or validity domain).

mMl_l <- MINDEX_SP(sim_dat[,c(1,2)], scaleQ, m, 5, xlim_l, ylim_l)
mMl_s <- MINDEX_SP(sim_dat[,c(1,2)], scaleQ, m, 5, xlim_s, ylim_s)

## End(Not run)
Description

Estimates the intrinsic dimension of data using the Morisita estimator of intrinsic dimension.

Usage

MINDID(X, scaleQ=1:5, mMin=2, mMax=2)

Arguments

X A N × E matrix, data.frame or data.table where N is the number of data points and E is the number of variables (or features). Each variable is rescaled to the [0,1] interval by the function.

scaleQ Either a single value or a vector. It contains the value(s) of elli chosen by the user (by default: scaleQ = 1:5).

mMin The minimum value of m (by default: mMin = 2).

mMax The maximum value of m (by default: mMax = 2).

Details

1. elli is the edge length of the grid cells (or quadrats). Since the variables (and consequently the grid) are rescaled to the [0,1] interval, elli is equal to 1 for a grid consisting of only one cell.

2. elli = 1 is the number of grid cells (or quadrats) along each axis of the Euclidean space in which the data points are embedded.

3. elli = 1 is equal to Q (1/E) where Q is the number of grid cells and E is the number of variables (or features).

4. elli is directly related to δ (see References).

5. δ is the diagonal length of the grid cells.

Value

A list of two elements:

1. a data.frame containing the ln value of the m-Morisita index for each value of ln(δ) and m.
   The values of ln(δ) are provided with regard to the [0,1] interval.

2. a data.frame containing the values of S_m and M_m for each value of m.

Author(s)

Jean Golay <Jean.Golay@unil.ch>
**RenDim**

**References**


**Examples**

```r
sim_dat <- SwissRoll(1000)

scaleQ <- 1:15 # It starts with a grid of 1^E cell (or quadrat).
# It ends with a grid of 15^E cells (or quadrats).
mMI_ID <- MINDID(sim_dat, scaleQ[5:15])

print(paste("The ID estimate is equal to", round(mMI_ID[1] [[1, 3], 2])))
```

---

**RenDim**

**Renyi’s Generalized Dimensions**

**Description**

Estimates Rényi’s generalized dimensions (or Rényi’s dimensions of $q^{th}$ order). It is mainly for $q = 2$ that the result is used as an estimate of the intrinsic dimension of data.

**Usage**

```r
RenDim(X, scaleQ=1:5, qMin=2, qMax=2)
```

**Arguments**

- **X**: A $N \times E$ matrix, `data.frame` or `data.table` where $N$ is the number of data points and $E$ is the number of variables (or features). Each variable is rescaled to the [0,1] interval by the function.

- **scaleQ**: Either a single value or a vector. It contains the value(s) of $\ell^{-1}$ chosen by the user (by default: `scaleQ = 1:5`).

- **qMin**: The minimum value of $q$ (by default: `qMin = 2`).

- **qMax**: The maximum value of $q$ (by default: `qMax = 2`).
Details

1. $\ell$ is the edge length of the grid cells (or quadrats). Since the variables (and consequently the grid) are rescaled to the $[0, 1]$ interval, $\ell$ is equal to 1 for a grid consisting of only one cell.

2. $\ell^{-1}$ is the number of grid cells (or quadrats) along each axis of the Euclidean space in which the data points are embedded.

3. $\ell^{-1}$ is equal to $Q^{(1/E)}$ where $Q$ is the number of grid cells and $E$ is the number of variables (or features).

4. $\ell^{-1}$ is directly related to $\delta$ (see References).

5. $\delta$ is the diagonal length of the grid cells.

Value

A list of two elements:

1. a data.frame containing the value of Rényi’s information of $q^{th}$ order (computed using the natural logarithm) for each value of $\ln(\delta)$ and $q$. The values of $\ln(\delta)$ are provided with regard to the $[0, 1]$ interval.

2. a data.frame containing the value of $D_q$ for each value of $q$.

Author(s)

Jean Golay <Jean.Golay@unil.ch>

References


Examples

```r
sim_dat <- SwissRoll(1000)

scaleQ <- 1:15  # It starts with a grid of 1^E cell (or quadrat).
                # It ends with a grid of 15^E cells (or quadrats).
qRI_ID <- RenDim(sim_dat[,c(1,2)], scaleQ[5:15])

print(paste("The ID estimate is equal to",round(qRI_ID[[1]][1,2],2)))
```
**SwissRoll**

Swiss Roll Data Set Generator

**Description**

Generates random points on the Swiss Roll manifold.

**Usage**

`SwissRoll(N=10000)`

**Arguments**

- `N` The number of points to be generated (by default: `N = 10000`).

**Value**

A `N x 3` data frame containing the coordinates of the Swiss roll data points embedded in $\mathbb{R}^3$.

**References**


**Examples**

```r
sim_dat <- SwissRoll(1000)
```
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