

# Package ‘clusterSim’

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**Title** Searching for Optimal Clustering Procedure for a Data Set

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**Depends** cluster, MASS

**Imports** ade4, e1071, rgl, R2HTML, modeest, grDevices, graphics, stats, utils

**Suggests** mlbench, testthat

**Description** Distance measures (GDM1, GDM2, Sokal-Michener, Bray-Curtis, for symbolic interval-valued data), cluster quality indices (Calinski-Harabasz, Baker-Hubert, Hubert-Levine, Silhouette, Krzanowski-Lai, Hartigan, Gap, Davies-Bouldin), data normalization formulas (metric data, interval-valued symbolic data), data generation (typical and non-typical data), HI-NoV method, replication analysis, linear ordering methods, spectral clustering, agreement indices between two partitions, plot functions (for categorical and symbolic interval-valued data). (MILLIGAN, G.W., COOPER, M.C. (1985) <doi:10.1007/BF02294245>, HUBERT, L., ARABIE, P. (1985), <doi:10.1007%2FBF01908075>, RAND, W.M. (1971) <doi:10.1080/01621459.1971.10482356>, JAJUGA, K., WALESIAK, M. (2000) <doi:10.1007/978-3-642-57280-7\_11>, MILLIGAN, G.W., COOPER, M.C. (1988) <doi:10.1007/BF01897163>, CORMACK, R.M. (1971) <doi:10.2307/2344237>, JAJUGA, K., WALESIAK, M., BAK, A. (2003) <doi:10.1007/978-3-642-55721-7\_12>, CARMONE, F.J., KARA, A., MAXWELL, S. (1999) <doi:10.2307/3152003>, DAVIES, D.L., BOULDIN, D.W. (1979) <doi:10.1109/TPAMI.1979.4766909>, CALINSKI, T., HARABASZ, J. (1974) <doi:10.1080/03610927408827101>, HUBERT, L. (1974) <doi:10.1080/01621459.1974.10480191>, TIBSHIRANI, R., WALTHER, G., HASTIE, T. (2001) <doi:10.1111/1467-9868.00293>, KRZANOWSKI, W.J., LAI, Y.T. (1988) <doi:10.2307/2531893>, BRECKENRIDGE, J.N. (2000) <doi:10.1207/S15327906MBR3502\_5>, WALESIAK, M., DUDEK, A. (2008) <doi:10.1007/978-3-540-78246-9\_11>).

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`cluster.Description`     *Descriptive statistics calculated separately for each cluster and variable*

### Description

Descriptive statistics calculated separately for each cluster and variable: arithmetic mean and standard deviation, median and median absolute deviation, mode

### Usage

```
cluster.Description(x, cl, sdType="sample",precision=4,modeAggregationChar=";")
```

### Arguments

<code>x</code>	matrix or dataset
<code>cl</code>	a vector of integers indicating the cluster to which each object is allocated
<code>sdType</code>	type of standard deviation: for "sample" (n-1) or for "population" (n)
<code>precision</code>	Number of digits on the right side of decimal mark sign
<code>modeAggregationChar</code>	Character used for aggregation of mode values (if more than one value of mode appear in variable)

### Value

Three-dimensional array:

First dimension contains cluster number

Second dimension contains original coordinate (variable) number from matrix or data set

Third dimension contains number from 1 to 5:

1 - arithmetic mean

2 - standard deviation

3 - median

4 - median absolute deviation (mad)

5 - mode (value of the variable which has the largest observed frequency. This formula is applicable for nominal and ordinal data only).

For example:

```
desc<-cluster.Description(x,cl)
```

desc[2,4,2] - standard deviation of fourth coordinate of second cluster  
 desc[3,1,5] - mode of first coordinate (variable) of third cluster  
 desc[1,,] - all statistics for all dimensions (variables) of first cluster  
 desc[,3] - medians of all dimensions (variables) for each cluster

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### See Also

[cluster.Sim](#), [mean](#), [sd](#), [median](#), [mad](#)

### Examples

```
library(clusterSim)
data(data_ratio)
cl <- pam(data_ratio,5)
desc <- cluster.Description(data_ratio,cl$cluster)
print(desc)
```

---

cluster.Gen

*Random cluster generation with known structure of clusters*

---

### Description

Random cluster generation with known structure of clusters (optionally with noisy variables and outliers)

### Usage

```
cluster.Gen(numObjects=50, means=NULL, cov=NULL, fixedCov=TRUE,
            model=1, dataType="m", numCategories=NULL,
            numNoisyVar=0, numOutliers=0, rangeOutliers=
            c(1,10), inputType="csv2", inputHeader=TRUE,
            inputRowNames=TRUE, outputCsv="", outputCsv2="",
            outputColNames=TRUE, outputRowNames=TRUE)
```

### Arguments

numObjects	number of objects in each cluster - positive integer value or vector with the same size as <i>nrow(means)</i> , e.g. <code>numObjects=c(50,20)</code>
means	matrix of cluster means (e.g. <code>means=matrix(c(0,8,0,8),2,2)</code> ). If <code>means = NULL</code> matrix should be read from <code>means\_&lt;modelNumber&gt;.csv file</code>

cov	covariance matrix (the same for each cluster, e.g. <code>cov=matrix(c(1, 0, 0, 1), 2, 2)</code> ). If <code>cov=NULL</code> matrix should be read from <code>cov\<i>&lt;modelName&gt;</i>.csv</code> file. Note: you cannot use this argument for generation of clusters with different covariance matrices. Those kind of generation should be done by setting <code>fixedCov</code> to <code>FALSE</code> and using appropriate model
model	model number, <code>model=1</code> - no cluster structure. Observations are simulated from uniform distribution over the unit hypercube in number of dimensions (variables) given in <code>numNoisyVar</code> argument; <code>model=2</code> - means and covariances are taken from arguments <code>means</code> and <code>cov</code> (see Example 1); <code>model=3, 4, . . . , 20</code> - see file <code>\\$R\_HOME\library\clusterSim\pdf\clusterGen\_details.pdf</code> ; <code>model=21, 22, . . .</code> - if <code>fixedCov=TRUE</code> means should be read from <code>means\<i>&lt;modelName&gt;</i>.csv</code> and covariance matrix for all clusters should be read from <code>cov\<i>&lt;modelName&gt;</i>.csv</code> and if <code>fixedCov=FALSE</code> means should be read from <code>means\<i>&lt;modelName&gt;</i>.csv</code> and covariance matrices should be read separately for each cluster from <code>cov\<i>&lt;modelName&gt;</i>\_<i>&lt;clusterNumber&gt;</i>.csv</code>
fixedCov	if <code>fixedCov=TRUE</code> covariance matrix for all clusters is the same and if <code>fixedCov=FALSE</code> each cluster is generated from different covariance matrix - see <code>model</code>
dataType	"m" - metric (ratio, interval), "o" - ordinal, "s" - symbolic interval
numCategories	number of categories (for ordinal data only). Positive integer value or vector with the same size as <code>ncol(means)</code> plus number of noisy variables.
numNoisyVar	number of noisy variables. For <code>model=1</code> it means number of variables
numOutliers	number of outliers (for metric and symbolic interval data only). If a positive integer - number of outliers, if value from <code>&lt;0,1&gt;</code> - percentage of outliers in whole data set
rangeOutliers	range for outliers (for metric and symbolic interval data only). The default range is <code>[1, 10]</code> . The outliers are generated independently for each variable for the whole data set from uniform distribution. The generated values are randomly added to maximum of <i>j</i> -th variable or subtracted from minimum of <i>j</i> -th variable
inputType	"csv" - a dot as decimal point or "csv2" - a comma as decimal point in <code>means\<i>&lt;modelName&gt;</i>.csv</code> and <code>cov\<i>&lt;modelName&gt;</i>.csv</code> files
inputHeader	<code>inputHeader=TRUE</code> indicates that input files ( <code>means\<i>&lt;modelName&gt;</i>.csv</code> ; <code>cov\<i>&lt;modelName&gt;</i>...<i>&gt;</i>.csv</code> ) contain header row
inputRowNames	<code>inputRowNames=TRUE</code> indicates that input files ( <code>means\<i>&lt;modelName&gt;</i>.csv</code> ; <code>cov\<i>&lt;modelName&gt;</i>...<i>&gt;</i>.csv</code> ) contain first column with row names or with number of objects (positive integer values)
outputCsv	optional, name of csv file with generated data (first column contains id, second - number of cluster and others - data)
outputCsv2	optional, name of csv (a comma as decimal point and a semicolon as field separator) file with generated data (first column contains id, second - number of cluster and others - data)

- outputColNames outputColNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains first row with column names
- outputRowNames outputRowNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains a vector of row names

### Details

See file `\$R\_HOME\library\clusterSim\pdf\clusterGen\_details.pdf` for further details

### Value

- clusters cluster number for each object, for model=1 each object belongs to its own cluster thus this variable contains objects numbers
- data generated data: for metric and ordinal data - matrix with objects in rows and variables in columns; for symbolic interval data three-dimensional structure: first dimension represents object number, second - variable number and third dimension contains lower- and upper-bounds of intervals

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**Examples**

```

# Example 1
library(clusterSim)
means <- matrix(c(0,7,0,7),2,2)
cov <- matrix(c(1,0,0,1),2,2)
grnd <- cluster.Gen(numObjects=60,means=means,cov=cov,model=2,
numOutliers=8)
colornames <- c("red","blue","green")
grnd$clusters[grnd$clusters==0]<-length(colornames)
plot(grnd$data,col=colornames[grnd$clusters],ask=TRUE)

# Example 2
library(clusterSim)
grnd <- cluster.Gen(50,model=4,dataType="m",numNoisyVar=2)
data <- as.matrix(grnd$data)
colornames <- c("red","blue","green")
plot(grnd$data,col=colornames[grnd$clusters],ask=TRUE)

# Example 3
library(clusterSim)
grnd<-cluster.Gen(50,model=4,dataType="o",numCategories=7, numNoisyVar=2)
plotCategorical(grnd$data,,grnd$clusters,ask=TRUE)

# Example 4 (1 nonnoisy variable and 2 noisy variables, 3 clusters)
library(clusterSim)
grnd <- cluster.Gen(c(40,60,20), model=2, means=c(2,14,25),
cov=c(1.5,1.5,1.5),numNoisyVar=2)
colornames <- c("red","blue","green")
plot(grnd$data,col=colornames[grnd$clusters],ask=TRUE)

# Example 5
library(clusterSim)
grnd <- cluster.Gen(c(20,35,20,25),model=14,dataType="m",numNoisyVar=1,
fixedCov=FALSE, numOutliers=0.1, outputCsv2="data14.csv")
data <- as.matrix(grnd$data)
colornames <- c("red","blue","green","brown","black")
grnd$clusters[grnd$clusters==0]<-length(colornames)
plot(grnd$data,col=colornames[grnd$clusters],ask=TRUE)

# Example 6 (this example needs files means_24.csv)
# and cov_24.csv to be placed in working directory
# library(clusterSim)
# grnd<-cluster.Gen(c(50,80,20),model=24,dataType="m",numNoisyVar=1,
# numOutliers=10, rangeOutliers=c(1,5))
# print(grnd)
# data <- as.data.frame(grnd$data)
# colornames<-c("red","blue","green","brown")
# grnd$clusters[grnd$clusters==0]<-length(colornames)
# plot(data,col=colornames[grnd$clusters],ask=TRUE)

```

```
# Example 7 (this example needs files means_25.csv and cov_25_1.csv)
# cov_25_2.csv, cov_25_3.csv, cov_25_4.csv, cov_25_5.csv
# to be placed in working directory
# library(clusterSim)
# grnd<-cluster.Gen(c(40,30,20,35,45),model=25,numNoisyVar=3,fixedCov=F)
# data <- as.data.frame(grnd$data)
# colnames<-c("red","blue","green","magenta","brown")
# plot(data,col=colnames[grnd$clusters],ask=TRUE)
```

---

cluster.Sim

*Determination of optimal clustering procedure for a data set*


---

### Description

Determination of optimal clustering procedure for a data set by varying all combinations of normalization formulas, distance measures, and clustering methods

### Usage

```
cluster.Sim (x,p,minClusterNo,maxClusterNo,icq="S",outputHtml="",
outputCsv="",outputCsv2="",normalizations=NULL,
distances=NULL,methods=NULL)
```

### Arguments

x	matrix or dataset
p	path of simulation: 1 - ratio data, 2 - interval or mixed (ratio & interval) data, 3 - ordinal data, 4 - nominal data, 5 - binary data, 6 - ratio data without normalization, 7 - interval or mixed (ratio & interval) data without normalization, 8 - ratio data with k-means, 9 - interval or mixed (ratio & interval) data with k-means
minClusterNo	minimal number of clusters, between 2 and no. of objects - 1 (for G3: no. of objects - 2)
maxClusterNo	maximal number of clusters, between 2 and no. of objects - 1 (for G3: no. of objects - 2; for KL: no. of objects - 3), greater or equal minClusterNo
icq	Internal cluster quality index, "S" - Silhouette,"G1" - Calinski & Harabasz index, "G2" - Baker & Hubert index ,"G3" - Hubert & Levine index, "KL" - Krzanowski & Lai index
outputHtml	optional, name of html file with results
outputCsv	optional, name of csv file with results
outputCsv2	optional, name of csv (comma as decimal point sign) file with results
normalizations	optional, vector of normalization formulas that should be used in procedure
distances	optional, vector of distance measures that should be used in procedure
methods	optional, vector of classification methods that should be used in procedure



**Details**

Parameter normalizations for each path may be the subset of the following values

path 1: "n6" to "n11" (if measurement scale of variables is ratio and transformed measurement scale of variables is ratio) or "n1" to "n5" (if measurement scale of variables is ratio and transformed measurement scale of variables is interval)

path 2: "n1" to "n5"

path 3 to 7 : "n0"

path 8: "n1" to "n11"

path 9: "n1" to "n5"

Parameter distances for each path may be the subset of the following values

path 1: "d1" to "d7" (if measurement scale of variables is ratio and transformed measurement scale of variables is ratio) or "d1" to "d5" (if measurement scale of variables is ratio and transformed measurement scale of variables is interval)

path 2: "d1" to "d5"

path 3: "d8"

path 4: "d9"

path 5: "b1" to "b10"

path 6: "d1" to "d7"

path 7: "d1" to "d5"

path 8 and 9: N.A.

Parameter methods for each path may be the subset of the following values

path 1 to 7 : "m1" to "m8"

path 8: "m9"

path 9: "m9"

See file [../doc/clusterSim\\_details.pdf](#) for further details

**Value**

result	optimal value of icq for all classifications
normalization	normalization used to obtain optimal value of icq
distance	distance measure used to obtain optimal value of icq
method	clustering method used to obtain optimal value of icq
classes	number of clusters for optimal value of icq
time	time of all calculations for path

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## See Also

[data.Normalization](#), [dist.GDM](#), [dist.BC](#), [dist.SM](#), [index.G1](#), [index.G2](#),  
[index.G3](#), [index.S](#), [index.KL](#), [hclust](#), [dist](#),

## Examples

```
library(clusterSim)
# Commented due to long execution time
#data(data_ratio)
#cluster.Sim(data_ratio, 1, 2, 3, "G1", outputCsv="results1")
#data(data_interval)
#cluster.Sim(data_interval, 2, 2, 4, "G1", outputHtml="results2")
#data(data_ordinal)
#cluster.Sim(data_ordinal, 3, 2, 4, "G2", outputCsv2="results3")
#data(data_nominal)
#cluster.Sim(data_nominal, p=4, 2, 4, icq="G3", outputHtml="results4", methods=c("m2", "m3", "m5"))
#data(data_binary)
#cluster.Sim(data_binary, p=5, 2, 4, icq="S", outputHtml="results5", distances=c("b1", "b3", "b6"))
data(data_ratio)
cluster.Sim(data_ratio, 1, 2, 4, "G1", outputCsv="results6", normalizations=c("n1", "n3"),
distances=c("d2", "d5"), methods=c("m5", "m3", "m1"))
```

---

comparing.Partitions *Calculate agreement indices between two partitions*

---

**Description**

Calculate agreement indices between two partitions

**Usage**

```
comparing.Partitions(c11,c12,type="nowak")
```

**Arguments**

c11	A vector of integers (or letters) indicating the cluster to which each object is allocated for first clustering
c12	A vector of integers (or letters) indicating the cluster to which each object is allocated for second clustering
type	"rand" - for Rand index, "crand" - for adjusted Rand index or "nowak" for Nowak index

**Details**

See file `\$R_HOME\library\clusterSim\pdf\comparingPartitions_details.pdf` for further details.

Rand and adjusted Rand indices uses `classAgreement` function from `e1071` library.

**Value**

Returns value of index.

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**References**

Hubert, L., Arabie, P. (1985), *Comparing partitions*, "Journal of Classification", no. 1, 193-218. Available at: <http://dx.doi.org/10.1007%2FBF01908075>.

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**See Also**[replication.Mod](#)**Examples**

```
# Example 1
library(clusterSim)
dataSet<-cluster.Gen(model=5)
c11<-dataSet$clusters
c12<-kmeans(dataSet$data,2)$cluster
print(comparing.Partitions(c11,c12,type="rand"))

# Example 2
library(clusterSim)
data(data_patternGDM1)
z<-data.Normalization(data_patternGDM1,type="n1")
d<-dist.GDM(z,method="GDM1")
c11<-pam(d,3,diss=TRUE)$clustering
c12<-pam(d,4,diss=TRUE)$clustering
print(comparing.Partitions(c11,c12,type="crand"))

# Example 3
library(clusterSim)
data(data_patternGDM1)
z<-data.Normalization(data_patternGDM1,type="n9")
d<-dist.GDM(z,method="GDM1")
c11<-pam(d,3,diss=TRUE)$clustering
hc<-hclust(d,method="complete")
c12<-cutree(hc,k=3)
print(comparing.Partitions(c11,c12,type="nowak"))
```

---

data.Normalization      *Types of variable (column) and object (row) normalization formulas*

---

**Description**

Types of variable (column) and object (row) normalization formulas

**Usage**

```
data.Normalization (x,type="n0",normalization="column")
```

**Arguments**

x	vector, matrix or dataset
type	type of normalization: n0 - without normalization n1 - standardization ((x-mean)/sd) n2 - positional standardization ((x-median)/mad)

n3 - unitization  $((x-\text{mean})/\text{range})$   
 n3a - positional unitization  $((x-\text{median})/\text{range})$   
 n4 - unitization with zero minimum  $((x-\text{min})/\text{range})$   
 n5 - normalization in range  $\langle -1, 1 \rangle$   $((x-\text{mean})/\max(\text{abs}(x-\text{mean})))$   
 n5a - positional normalization in range  $\langle -1, 1 \rangle$   $((x-\text{median})/\max(\text{abs}(x-\text{median})))$   
 n6 - quotient transformation  $(x/\text{sd})$   
 n6a - positional quotient transformation  $(x/\text{mad})$   
 n7 - quotient transformation  $(x/\text{range})$   
 n8 - quotient transformation  $(x/\text{max})$   
 n9 - quotient transformation  $(x/\text{mean})$   
 n9a - positional quotient transformation  $(x/\text{median})$   
 n10 - quotient transformation  $(x/\text{sum})$   
 n11 - quotient transformation  $(x/\sqrt{\text{SSQ}})$   
 n12 - normalization  $((x-\text{mean})/\sqrt{\text{sum}((x-\text{mean})^2)})$   
 n12a - positional normalization  $((x-\text{median})/\sqrt{\text{sum}((x-\text{median})^2)})$   
 n13 - normalization with zero being the central point  $((x-\text{midrange})/(\text{range}/2))$   
 normalization "column" - normalization by variable, "row" - normalization by object

### Details

See file [../doc/dataNormalization\\_details.pdf](#) for further details

### Value

Normalized data The numeric shifts and scalings used (if any) are returned as attributes "normalized:shift" and "normalized:scale"

### Author(s)

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Walesiak, M. (2014), *Przegląd formuł normalizacji wartości zmiennych oraz ich własności w statystycznej analizie wielowymiarowej [Data normalization in multivariate data analysis. An overview and properties]*, "Przegląd Statystyczny" ("Statistical Review"), vol. 61, no. 4, 363-372. Available at: [http://keii.ue.wroc.pl/pracownicy/mw/2014\\_Walesiak\\_Przeglad\\_Statystyczny\\_z\\_4.pdf](http://keii.ue.wroc.pl/pracownicy/mw/2014_Walesiak_Przeglad_Statystyczny_z_4.pdf).

### See Also

[cluster.Sim](#)

### Examples

```
library(clusterSim)
data(data_ratio)
z1 <- data.Normalization(data_ratio,type="n1",normalization="column")
z2 <- data.Normalization(data_ratio,type="n10",normalization="row")
```

---

data\_binary

*Binary data*

---

### Description

Binary variables for eight people

### Format

data.frame: 8 objects, 10 variables

### Source

Kaufman, L., Rousseeuw, P.J. (1990), *Finding groups in data: an introduction to cluster analysis*, Wiley, New York, p. 24.

### Examples

```
library(clusterSim)
data(data_binary)
cluster.Sim(data_binary, p=5, 2, 6, icq="S",
outputHtml="results5", distances=c("b1", "b3", "b6"))
```

---

data_interval	<i>Interval data</i>
---------------	----------------------

---

**Description**

Artificially generated interval data

**Format**

data.frame: 75 objects, 5 variables, 5-class structure

**Source**

Artificially generated data

**Examples**

```
library(clusterSim)
data(data_interval)
cluster.Sim(data_interval, 2, 2, 3, "G1", outputHtml="results2")
```

---

data_mixed	<i>Mixed data</i>
------------	-------------------

---

**Description**

Artificial mixed data

**Format**

data.frame: 25 objects, 4 variables (1, 3 - interval variables, 2 - ordinal variable, 4, nominal variable)

**Source**

Artificial data

**Examples**

```
library(clusterSim)
data(data_mixed)
r3 <- HINoV.Mod(data_mixed, type=c("m","n","m","n"), s=2, 3, distance="d1",
  method="complete", Index="cRAND")
print(r3$stopri)
plot(r3$stopri[,2], xlab="Variable number", ylab="topri", xaxt="n")
axis(1,at=c(1:max(r3$stopri[,1])),labels=r3$stopri[,1])
```

---

data_nominal	<i>Nominal data</i>
--------------	---------------------

---

**Description**

Artificial nominal data

**Format**

data.frame: 26 objects, 12 variables

**Source**

Artificial data

**Examples**

```
library(clusterSim)
data(data_nominal)
cluster.Sim(data_nominal, p=4, 2, 5, icq="G3",
outputHtml="results4", methods=c("m2", "m3", "m5"))
```

---

data_ordinal	<i>Ordinal data</i>
--------------	---------------------

---

**Description**

Artificial ordinal data

**Format**

data.frame: 26 objects, 12 variables

**Source**

Artificial data

**Examples**

```
library(clusterSim)
data(data_ordinal)
cluster.Sim(data_ordinal, 3, 3, 12, "S",
outputCsv2="results3")
```



---

data_patternGDM1	<i>Metric data with 17 objects and 10 variables (8 stimulant variables, 2 destimulant variables)</i>
------------------	--

---

### Description

Metric data with 17 objects and 10 variables (8 stimulant variables, 2 destimulant variables)

Data on the Polish voivodships, owing to the conditions of the population living in cities in 2007.

The analysis includes the following variables:

x1 - dwellings in per cent fitted with water-line system,

x2 - dwellings in per cent fitted with lavatory,

x3 - dwellings in per cent fitted with bathroom,

x4 - dwellings in per cent fitted with gas-line system,

x5 - dwellings in per cent fitted with central heating,

x6 - average number of rooms per dwelling,

x7 - average number of persons per dwelling,

x8 - average number of persons per room,

x9 - usable floor space in square meter per dwelling,

x10 - usable floor space in square meter per person.

Types of performance variables:

x1 - x6, x9, x10 - stimulants,

x7, x8 - destimulants.

### Format

data.frame: 17 objects, 10 variables

### Source

Voivodships Statistical Yearbook, Poland 2008.

### Examples

```
# Example 1
library(clusterSim)
data(data_patternGDM1)
res<-pattern.GDM1(data_patternGDM1,
performanceVariable=c("s","s","s","s","s","s","s","d","d","s","s"),
scaleType="r",nomOptValues=NULL,weightsType<-"equal",weights=NULL,
normalization<-"n4",patternType<-"lower",patternCoordinates<-"manual",
patternManual<-c(0,0,0,0,0,"min","max","max","min","min"),
nominalTransfMethod <-NULL)
print(res)
```

```

gdm_p<-res$distances
plot(cbind(gdm_p,gdm_p),xlim=c(max(gdm_p),min(gdm_p)),
ylim=c(min(gdm_p),max(gdm_p)),xaxt="n",
xlab="Order of objects from the best to the worst",
ylab="GDM distances from pattern object",lwd=1.6)
axis(1, at=gdm_p,labels=names(gdm_p), cex.axis=0.5)

# Example 2
library(clusterSim)
data(data_patternGDM1)
res<-pattern.GDM1(data_patternGDM1,
performanceVariable=c("s","s","s","s","s","s","d","d","s","s"),
scaleType="r",nomOptValues=NULL,weightsType<-"equal",weights=NULL,
normalization<-"n2",patternType<-"upper",
patternCoordinates<-"dataBounds",patternManual<-NULL,
nominalTransfMethod <-NULL)
print(res)
gdm_p<-res$distances
plot(cbind(gdm_p,gdm_p),xlim=c(min(gdm_p),max(gdm_p)),
ylim=c(min(gdm_p),max(gdm_p)),xaxt="n",
xlab="Order of objects from the best to the worst",
ylab="GDM distances from pattern object", lwd=1.6)
axis(1, at=gdm_p,labels=names(gdm_p), cex.axis=0.5)

```

---

data_patternGDM2	<i>Ordinal data with 27 objects and 6 variables (3 stimulant variables, 2 destimulant variables and 1 nominant variable)</i>
------------------	--

---

## Description

Ordinal data with 27 objects and 6 variables (3 stimulant variables, 2 destimulant variables and 1 nominant variable)

Residential housing properties were described by the following variables:

x1 - Location of environmental land, which is linked to a dwelling (1 - poor, 2 - inadequate, 3 - satisfactory, 4 - good, 5 - very good),

x2 - Standard utility of a dwelling (1 - bad, 2 - low, 3 - average, 4 - high),

x3 - Living conditions occurring on the land, which is linked to a dwelling (1 - bad, 2 - average, 3 - good),

x4 - Location of land, which is related to dwelling in the area of the city (1 - central, 2 - downtown, 3 - intermediate, 4 - peripheral),

x5 - Type of condominium (1 - low, 2 - large),

x6 - Area of land, which is related to dwelling (1 - below the contour of the building, 2 - outline of the building, 3 - the outline of the building with the environment acceptable, such as parking, playground, 4 - the outline of the building with the environment too much).

Types of performance variables:

x1, x2, x3 - stimulants,

x4, x5 - destimulants,  
 x6 - nominant (the nominal category: 3).

### Format

data.frame: 27 objects, 6 variables

### Source

data from real estate market

### Examples

```
# Example 1
library(clusterSim)
data(data_patternGDM2)
res<-pattern.GDM2(data_patternGDM2,
performanceVariable=c("s","s","s","d","d","n"),
nomOptValues=c(NA,NA,NA,NA,NA,3), weightsType<-"equal", weights=NULL,
patternType="lower", patternCoordinates="manual",
patternManual=c("min","min",0,5,"max","max"),
nominalTransfMethod="symmetrical")
print(res)
gdm_p<-res$distances
plot(cbind(gdm_p,gdm_p),xlim=c(max(gdm_p),min(gdm_p)),
ylim=c(min(gdm_p),max(gdm_p)),
xaxt="n",xlab="Order of objects from the best to the worst",
ylab="GDM distances from pattern object",lwd=1.6)
axis(1, at=gdm_p,labels=names(gdm_p), cex.axis=0.5)

# Example 2
library(clusterSim)
data(data_patternGDM2)
res<-pattern.GDM2(data_patternGDM2,
performanceVariable=c("s","s","s","d","d","n"),
nomOptValues=c(NA,NA,NA,NA,NA,3), weightsType<-"equal", weights=NULL,
patternType="upper", patternCoordinates="dataBounds",
patternManual=NULL, nominalTransfMethod="database")
print(res)
gdm_p<-res$distances
plot(cbind(gdm_p,gdm_p), xlim=c(min(gdm_p),max(gdm_p)),
ylim=c(min(gdm_p),max(gdm_p)),
xaxt="n",xlab="Order of objects from the best to the worst",
ylab="GDM distances from pattern object", lwd=1.6)
axis(1, at=gdm_p,labels=names(gdm_p), cex.axis=0.5)
```

---

data_ratio	<i>Ratio data</i>
------------	-------------------

---

**Description**

Artificially generated ratio data

**Format**

data.frame: 75 objects, 5 variables, 5-class structure

**Source**

Artificially generated data

**Examples**

```
library(clusterSim)
data(data_ratio)
c <- pam(data_ratio,10)
index.G1(data_ratio, c$clustering)
```

---

data_symbolic	<i>Symbolic interval data</i>
---------------	-------------------------------

---

**Description**

Artificially generated symbolic interval data

**Format**

3-dimensional array: 125 objects, 6 variables, third dimension represents beginning and end of interval, 5-class structure

**Source**

Artificially generated data

**Examples**

```
library(clusterSim)
data(data_symbolic)
r<- HINoV.Symbolic(data_symbolic, u=5)
print(r$stopri)
plot(r$stopri[,2], xlab="Variable number", ylab="topri",
xaxt="n", type="b")
axis(1,at=c(1:max(r$stopri[,1])),labels=r$stopri[,1])
```

---

data\_symbolic\_interval\_polish\_voivodships

*The evaluation of Polish voivodships tourism attractiveness level*

---

## Description

The empirical study uses the statistical data referring to the attractiveness level of 18 objects (16 Polish NUTS-2 regions - voivodships, pattern and anti-pattern object).

Two-stage data collection was performed. Firstly, data on tourist attractiveness were collected for 380 counties using 9 classic metric variables (measured on a ratio scale):

x1 - beds in hotels per 1000 inhabitants of a county,

x2 - number of nights spent daily by resident tourists (Poles) per 1000 inhabitants of a county,

x3 - number of nights spent daily by foreign tourists per 1000 inhabitants of a county,

x4 - dust pollution emission in tons per 10 km<sup>2</sup> of a county area,

x5 - gas pollution emission in tons per 1 km<sup>2</sup> of a county area,

x6 - number of criminal offences, crimes against life and health and property crimes per 1000 inhabitants of a county,

x7 - forest cover of the county in

x8 - participants of mass events per 1000 inhabitants of a county,

x9 - number of tourist economy entities (sections: I, N79) registered in the system REGON per 1000 inhabitants of a county.

The three variables (x4, x5 and x6) are destimulants. Other variables are stimulants.

In the second step, the data were aggregated to the level of the voivodships (NUTS-2), giving the symbolic interval-valued data. The lower bound of the interval for each symbolic interval-valued variable in the voivodship was obtained by calculating the first quartile on the basis of data from counties. The upper bound of the interval was obtained by calculating the third quartile.

## Format

Tree-dimensional array: 18 objects (16 Polish NUTS-2 regions - voivodships, pattern and anti-pattern object), 9 symbolic interval-valued variables with lower and upper values of interval in third dimension. The coordinates of a pattern object cover the most preferred preference variable values. The coordinates of an anti-pattern object cover the least preferred preference variable values.

## Source

The statistical data were collected in 2016 and come from the Local Data Bank of the Central Statistical Office of Poland.

## Examples

```
library(clusterSim)
data(data_symbolic_interval_polish_voivodships)
print(data_symbolic_interval_polish_voivodships)
```

---

dist.BC	<i>Calculates Bray-Curtis distance measure for ratio data</i>
---------	---

---

**Description**

Calculates Bray-Curtis distance measure for ratio data

**Usage**

```
dist.BC (x)
```

**Arguments**

x                   matrix or dataset

**Details**

See file `\$R\_HOME\library\clusterSim\pdf\distBC\_details.pdf` for further details

**Value**

object with calculated distance

**Author(s)**

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**References**

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Gatnar, E., Walesiak, M. (Eds.) (2004), *Metody statystycznej analizy wielowymiarowej w badaniach marketingowych [Multivariate statistical analysis methods in marketing research]*, Wydawnictwo AE, Wrocław, p. 41. Available at: [http://keii.ue.wroc.pl/pracownicy/mw/2004\\_Gatnar\\_Walesiak\\_Metody\\_SAW\\_w\\_badaniach\\_marketingowych.pdf](http://keii.ue.wroc.pl/pracownicy/mw/2004_Gatnar_Walesiak_Metody_SAW_w_badaniach_marketingowych.pdf).

**See Also**

[dist.GDM](#), [dist.SM](#), [dist](#)

**Examples**

```
library(clusterSim)
sampleData <- cbind(c(2,3,5),c(4,5,6),c(5,3,4))
d <- dist.BC(sampleData)
```

---

 dist.GDM

*Calculates Generalized Distance Measure*


---

**Description**

Calculates Generalized Distance Measure for variables measured on metric scale (ratio & interval) or ordinal scale

**Usage**

```
dist.GDM(x, method="GDM1", weightsType="equal", weights=NULL)
GDM(x, method="GDM1", weightsType="equal", weights=NULL)
GDM1(x, weightsType="equal", weights=NULL)
GDM2(x, weightsType="equal", weights=NULL)
```

**Arguments**

x	matrix or data set
method	GDM1 or GDM2 "GDM1" - metric scale (ratio & interval) "GDM2" - ordinal scale
weightsType	equal or different1 or different2 "equal" - equal weights "different1" - vector of different weights should satisfy conditions: each weight takes value from interval [0; 1] and sum of weights equals one "different2" - vector of different weights should satisfy conditions: each weight takes value from interval [0; m] and sum of weights equals m (m - the number of variables)
weights	vector of weights

**Details**

See file `\$R\_HOME\library\clusterSim\pdf\distGDM\_details.pdf` for further details

**Value**

object with calculated distance

**Author(s)**

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<http://keii.ue.wroc.pl/clusterSim>

## References

Jajuga, K., Walesiak, M., Bak, A. (2003), *On the general distance measure*, In: M. Schwaiger, O. Opitz (Eds.), *Exploratory data analysis in empirical research*, Springer-Verlag, Berlin, Heidelberg, 104-109. Available at: [http://dx.doi.org/10.1007/978-3-642-55721-7\\_12](http://dx.doi.org/10.1007/978-3-642-55721-7_12).

Walesiak, M. (1999), *Distance Measure for Ordinal Data*, "Argumenta Oeconomica", No. 2 (8), 167-173. Available at: [http://keii.ue.wroc.pl/pracownicy/mw/1999\\_Walesiak\\_Argumenta\\_Oeconomica\\_no\\_2.pdf](http://keii.ue.wroc.pl/pracownicy/mw/1999_Walesiak_Argumenta_Oeconomica_no_2.pdf).

Walesiak, M. (2006), *Uogolniona miara odleglosci w statystycznej analizie wielowymiarowej [The Generalized Distance Measure in multivariate statistical analysis]*, Wydawnictwo AE, Wroclaw. Available at: [http://keii.ue.wroc.pl/pracownicy/mw/2006\\_Walesiak\\_Uogolniona\\_miara\\_odleglosci.pdf](http://keii.ue.wroc.pl/pracownicy/mw/2006_Walesiak_Uogolniona_miara_odleglosci.pdf).

## See Also

[dist.BC](#), [dist.SM](#), [dist](#)

## Examples

```
#Example 1
library(clusterSim)
data(data_ratio)
d1 <- GDM(data_ratio, method="GDM1")
data(data_ordinal)
d2 <- GDM(data_ordinal, method="GDM2")
d3 <- GDM1(data_ratio)
d4 <- GDM2(data_ordinal)

#Example 2
library(clusterSim)
data(data_ratio)
d1w <- GDM(data_ratio, method="GDM1", weightsType="different1",
weights=c(0.4,0.1,0.3,0.15,0.05))
data(data_ordinal)
d2w <- GDM(data_ordinal, method="GDM2", weightsType="different2",
weights=c(1,3,0.5,1.5,1.8,0.2,0.4,0.6,0.2,0.4,0.9,1.5))
```

---

dist.SM

*Calculates Sokal-Michener distance measure for nominal variables*

---

## Description

Calculates Sokal-Michener distance measure for nominal variables

## Usage

dist.SM(x)



**Arguments**

x                    matrix or data set

**Details**

See file `\$R\_HOME\library\clusterSim\pdf\distSM\_details.pdf` for further details

**Value**

object with calculated distance

**Author(s)**

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<http://keii.ue.wroc.pl/clusterSim>

**References**

Gatnar, E., Walesiak, M. (Eds.) (2004), *Metody statystycznej analizy wielowymiarowej w badaniach marketingowych [Multivariate statistical analysis methods in marketing research]*, Wydawnictwo AE, Wrocław, p. 43. Available at: [http://keii.ue.wroc.pl/pracownicy/mw/2004\\_Gatnar\\_Walesiak\\_Metody\\_SAW\\_w\\_badaniach\\_marketingowych.pdf](http://keii.ue.wroc.pl/pracownicy/mw/2004_Gatnar_Walesiak_Metody_SAW_w_badaniach_marketingowych.pdf).

Kaufman, L., Rousseeuw, P.J. (1990), *Finding groups in data: an introduction to cluster analysis*, Wiley, New York, p. 28. ISBN: 978-0-471-73578-6.

**See Also**

[dist.GDM](#), [dist.BC](#), [dist](#)

**Examples**

```
library(clusterSim)
data(data_nominal)
d <- dist.SM(data_nominal)
```

---

dist.Symbolic                    *Calculates distance between interval-valued symbolic data*

---

**Description**

Calculates distance between interval-valued symbolic data for four distance types

**Usage**

```
dist.Symbolic(data, type="U_2", gamma=0.5, power=2)
```

**Arguments**

data	symbolic data
type	type of distance used for symbolic interval-valued data U_2 - Ichino and Yaguchi distance M - distance between points given by means of intervals (for interval-values variables), H - Hausdorff distance, S - sum of distances between all corresponding vertices of hyperrectangles given by symbolic objects with interval-valued variables
gamma	parameter for calculating Ichino and Yaguchi distance
power	parameter for calculating distance: Ichino and Yaguchi distance, Hausdorff distance

**Author(s)**

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**References**

Billard, L., Diday, E. (2006), *Symbolic data analysis. Conceptual statistics and data mining*, Wiley, Chichester. ISBN: 978-0-470-09016-9.

Ichino, M., Yaguchi, H. (1994), *Generalized Minkowski metrics for mixed feature type data analysis*, "IEEE Transactions on Systems Man and Cybernetics", Vol. 24, Issue 4, 698-708. <http://dx.doi.org/10.1109/21.286391>.

**See Also**

symbolicDA::dist.SDA

**Examples**

```
library(clusterSim)
dataSymbolic<-cluster.Gen(numObjects=10,model=5,dataType="s")$data
print(dist.Symbolic(dataSymbolic))
```

---

HINoV.Mod

*Modification of Carmone, Kara & Maxwell Heuristic Identification of Noisy Variables (HINoV) method*

---

**Description**

Modification of Heuristic Identification of Noisy Variables (HINoV) method

**Usage**

```
HINoV.Mod (x, type="metric", s = 2, u, distance=NULL,
method = "kmeans", Index ="cRAND")
```

**Arguments**

x	data matrix
type	"metric" (default) - all variables are metric (ratio, interval), "nonmetric" - all variables are nonmetric (ordinal, nominal) or vector containing for each variable value "m"(metric) or "n"(nonmetric) for mixed variables (metric and nonmetric), e.g. type=c("m", "n", "n", "m")
s	for metric data only: 1 - ratio data, 2 - interval or mixed (ratio & interval) data
u	number of clusters (for metric data only)
distance	NULL for kmeans method (based on data matrix) and nonmetric data for ratio data: "d1" - Manhattan, "d2" - Euclidean, "d3" - Chebychev (max), "d4" - squared Euclidean, "d5" - GDM1, "d6" - Canberra, "d7" - Bray-Curtis for interval or mixed (ratio & interval) data: "d1", "d2", "d3", "d4", "d5"
method	NULL for nonmetric data clustering method: "kmeans" (default) , "single", "ward.D", "ward.D2", "complete", "average", "mcquitty", "median", "centroid", "pam"
Index	"cRAND" - corrected Rand index (default); "RAND" - Rand index

**Details**

See file [../doc/HINoVMod\\_details.pdf](#) for further details

**Value**

parim	$m \times m$ symmetric matrix ( $m$ - number of variables). Matrix contains pairwise corrected Rand (Rand) indices for partitions formed by the $j$ -th variable with partitions formed by the $l$ -th variable
topri	sum of rows of parim
stopri	ranked values of topri in decreasing order

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### See Also

[hclust](#), [kmeans](#), [dist](#), [dist.GDM](#), [dist.BC](#), [dist.SM](#), [cluster.Sim](#)

### Examples

```
# for metric data
library(clusterSim)
data(data_ratio)
r1<- HINoV.Mod(data_ratio, type="metric", s=1, 4, method="kmeans",
  Index="cRAND")
print(r1$stopri)
plot(r1$stopri[,2],xlab="Variable number", ylab="topri",
xaxt="n", type="b")
axis(1,at=c(1:max(r1$stopri[,1])),labels=r1$stopri[,1])

# for nonmetric data
library(clusterSim)
data(data_nominal)
r2<- HINoV.Mod (data_nominal, type="nonmetric", Index = "cRAND")
print(r2$stopri)
plot(r2$stopri[,2], xlab="Variable number", ylab="topri",
xaxt="n", type="b")
axis(1,at=c(1:max(r2$stopri[,1])),labels=r2$stopri[,1])

# for mixed data
library(clusterSim)
data(data_mixed)
r3<- HINoV.Mod(data_mixed, type=c("m","n","m","n"), s=2, 3, distance="d1",
  method="complete", Index="cRAND")
print(r3$stopri)
plot(r3$stopri[,2], xlab="Variable number", ylab="topri",
xaxt="n", type="b")
axis(1,at=c(1:max(r3$stopri[,1])),labels=r3$stopri[,1])
```

---

HINoV.Symbolic	<i>Modification of Carmone, Kara &amp; Maxwell Heuristic Identification of Noisy Variables (HINoV) method for symbolic interval data</i>
----------------	--

---

**Description**

Modification of Heuristic Identification of Noisy Variables (HINoV) method for symbolic interval data

**Usage**

```
HINoV.Symbolic(x, u=NULL, distance="H", method = "pam",
Index = "cRAND")
```

**Arguments**

x	symbolic interval data: a 3-dimensional table, first dimension represents object number, second dimension - variable number, and third dimension contains lower- and upper-bounds of intervals
u	number of clusters
distance	"M" - minimal distance between all vertices of hyper-cubes defined by symbolic interval variables; "H" - Hausdorff distance; "S" - sum of squares of distance between all vertices of hyper-cubes defined by symbolic interval variables
method	clustering method: "single", "ward.D", "ward.D2", "complete", "average", "mcquitty", "median", "centroid", "pam" (default)
Index	"cRAND" - corrected Rand index (default); "RAND" - Rand index

**Details**

See file [../doc/HINoVSymbolic\\_details.pdf](#) for further details

**Value**

parim	$m \times m$ symmetric matrix ( $m$ - number of variables). Matrix contains pairwise corrected Rand (Rand) indices for partitions formed by the $j$ -th variable with partitions formed by the $l$ -th variable
topri	sum of rows of parim
stopri	ranked values of topri in decreasing order

**Author(s)**

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## References

Carmone, F.J., Kara, A., Maxwell, S. (1999), *HINoV: a new method to improve market segment definition by identifying noisy variables*, "Journal of Marketing Research", November, vol. 36, 501-509. Available at: <http://dx.doi.org/10.2307/3152003>

Hubert, L.J., Arabie, P. (1985), *Comparing partitions*, "Journal of Classification", no. 1, 193-218. Available at: <http://dx.doi.org/10.1007%2FBF01908075>.

Rand, W.M. (1971), *Objective criteria for the evaluation of clustering methods*, "Journal of the American Statistical Association", no. 336, 846-850. Available at: <http://dx.doi.org/10.1080/01621459.1971.10482356>.

Walesiak, M., Dudek, A. (2008), *Identification of noisy variables for nonmetric and symbolic data in cluster analysis*, In: C. Preisach, H. Burkhardt, L. Schmidt-Thieme, R. Decker (Eds.), *Data analysis, machine learning and applications*, Springer-Verlag, Berlin, Heidelberg, 85-92. Available at: [http://keii.ue.wroc.pl/pracownicy/mw/2010\\_Walesiak\\_Dudek\\_Springer.PDF](http://keii.ue.wroc.pl/pracownicy/mw/2010_Walesiak_Dudek_Springer.PDF)

## See Also

[hclust](#), [kmeans](#), [cluster.Sim](#)

## Examples

```
library(clusterSim)
data(data_symbolic)
r<- HINoV.Symbolic(data_symbolic, u=5)
print(r$stopri)
plot(r$stopri[,2], xlab="Variable number", ylab="topri",
xaxt="n", type="b")
axis(1,at=c(1:max(r$stopri[,1])),labels=r$stopri[,1])

#symbolic data from .csv file
#library(clusterSim)
#dsym<-as.matrix(read.csv2(file="csv/symbolic.csv"))
#dim(dsym)<-c(dim(dsym)[1],dim(dsym)[2]%/%2,2)
#r<- HINoV.Symbolic(dsym, u=5)
#print(r$stopri)
#plot(r$stopri[,2], xlab="Variable number", ylab="topri",
#xaxt="n", type="b")
#axis(1,at=c(1:max(r$stopri[,1])),labels=r$stopri[,1])
```

---

index.DB

*Calculates Davies-Bouldin's index*

---

## Description

Calculates Davies-Bouldin's cluster separation measure

**Usage**

```
index.DB(x, c1, d=NULL, centrotypes="centroids", p=2, q=2)
```

**Arguments**

x	data
c1	vector of integers indicating the cluster to which each object is allocated
d	optional distance matrix, used for calculations if centrotypes="medoids"
centrotypes	"centroids" or "medoids"
p	the power of the Minkowski distance between centroids or medoids of clusters: p=1 - Manhattan distance; p=2 - Euclidean distance
q	the power of dispersion measure of a cluster: q=1 - the average distance of objects in the r-th cluster to the centroid or medoid of the r-th cluster; q=2 - the standard deviation of the distance of objects in the r-th cluster to the centroid or medoid of the r-th cluster

**Details**

See file [../doc/indexDB\\_details.pdf](#) for further details

Thanks to prof. Christian Hennig <c.hennig@ucl.ac.uk> for finding and fixing the "immutable p" error

**Value**

DB	Davies-Bouldin's index
r	vector of maximal R values for each cluster
R	R matrix $(S_r + S_s) / d_{rs}$
d	matrix of distances between centroids or medoids of clusters
S	vector of dispersion measures for each cluster
centers	coordinates of centroids or medoids for all clusters

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**References**

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**See Also**

[index.G1](#), [index.G2](#), [index.G3](#), [index.S](#), [index.H](#), [index.Gap](#), [index.KL](#)

**Examples**

```

# Example 1
library(clusterSim)
data(data_ratio)
cl1 <- pam(data_ratio, 4)
d<-dist(data_ratio)
print(index.DB(data_ratio, cl1$clustering,d, centrotypes="medoids"))

# Example 2
library(clusterSim)
data(data_ratio)
cl2 <- pam(data_ratio, 5)
print(index.DB(data_ratio, cl2$clustering, centrotypes="centroids"))

# Example 3
library(clusterSim)
data(data_ratio)
md <- dist(data_ratio, method="euclidean")
# nc - number_of_clusters
min_nc=2
max_nc=8
res <- array(0, c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
clusters <- NULL
for (nc in min_nc:max_nc)
{
hc <- hclust(md, method="complete")
cl2 <- cutree(hc, k=nc)
res[nc-min_nc+1, 2] <- DB <- index.DB(data_ratio, cl2, centrotypes="centroids")$DB
clusters <- rbind(clusters, cl2)
}
print(paste("min DB for", (min_nc:max_nc)[which.min(res[,2])], "clusters=", min(res[,2])))
print("clustering for min DB")
print(clusters[which.min(res[,2]),])
write.table(res, file="DB_res.csv", sep=";", dec=".", row.names=TRUE, col.names=FALSE)
plot(res, type="p", pch=0, xlab="Number of clusters", ylab="DB", xaxt="n")
axis(1, c(min_nc:max_nc))

# Example 4
library(clusterSim)
data(data_ordinal)
md <- dist.GDM(data_ordinal, method="GDM2")
# nc - number_of_clusters
min_nc=2
max_nc=6
res <- array(0, c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
clusters <- NULL
for (nc in min_nc:max_nc)
{
hc <- hclust(md, method="complete")
cl2 <- cutree(hc, k=nc)

```



```

res[nc-min_nc+1,2] <- DB <- index.DB(data_ordinal,c12,d=md,centrotypes="medoids")$DB
clusters <- rbind(clusters, c12)
}
print(paste("min DB for", (min_nc:max_nc)[which.min(res[,2])], "clusters=", min(res[,2])))
print("clustering for min DB")
print(clusters[which.min(res[,2]),])
write.table(res, file="DB_res.csv", sep=";", dec=".", row.names=TRUE, col.names=FALSE)
plot(res, type="p", pch=0, xlab="Number of clusters", ylab="DB", xaxt="n")
axis(1, c(min_nc:max_nc))

```

---

index.G1

*Calculates Calinski-Harabasz pseudo F-statistic*


---

### Description

Calculates Calinski-Harabasz pseudo F-statistic

### Usage

```
index.G1 (x,c1,d=NULL,centrotypes="centroids")
```

### Arguments

x	data
c1	A vector of integers indicating the cluster to which each object is allocated
d	optional distance matrix, used for calculations if centrotypes="medoids"
centrotypes	"centroids" or "medoids"

### Details

See file [../doc/indexG1\\_details.pdf](#) for further details.

thank to Nejc Ilc from University of Ljubljana for fixing error for one-element clusters.

### Value

Calinski-Harabasz pseudo F-statistic

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## See Also

[index.G2](#), [index.G3](#), [index.S](#), [index.H](#), [index.KL](#), [index.Gap](#), [index.DB](#)

## Examples

```
# Example 1
library(clusterSim)
data(data_ratio)
c<- pam(data_ratio,10)
index.G1(data_ratio,c$clustering)

# Example 2
library(clusterSim)
data(data_ratio)
md <- dist(data_ratio, method="euclidean")
# nc - number_of_clusters
min_nc=2
max_nc=20
res <- array(0,c(max_nc-min_nc+1,2))
res[,1] <- min_nc:max_nc
clusters <- NULL
for (nc in min_nc:max_nc)
{
  cl2 <- pam(md, nc, diss=TRUE)
  res[nc-min_nc+1,2] <- G1 <- index.G1(data_ratio,cl2$cluster,centrotypes="centroids")
  clusters <- rbind(clusters, cl2$cluster)
}
print(paste("max G1 for", (min_nc:max_nc)[which.max(res[,2])], "clusters=", max(res[,2])))
print("clustering for max G1")
print(clusters[which.max(res[,2]),])
write.table(res, file="G1_res.csv", sep=";", dec=".", row.names=TRUE, col.names=FALSE)
plot(res, type="p", pch=0, xlab="Number of clusters", ylab="G1", xaxt="n")
axis(1, c(min_nc:max_nc))
```

---

`index.G2`*Calculates G2 internal cluster quality index*

---

**Description**

Calculates G2 internal cluster quality index - Baker & Hubert adaptation of Goodman & Kruskal's Gamma statistic

**Usage**`index.G2(d, c1)`**Arguments**

<code>d</code>	'dist' object
<code>c1</code>	A vector of integers indicating the cluster to which each object is allocated

**Details**

See file `\\$R_HOME\library\clusterSim\pdf\indexG2_details.pdf` for further details

**Value**

calculated G2 index

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**References**

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- Milligan, G.W., Cooper, M.C. (1985), *An examination of procedures of determining the number of cluster in a data set*, "Psychometrika", vol. 50, no. 2, 159-179. Available at: <https://dx.doi.org/10.1007/BF02294245>.

**See Also**

[index.G1](#), [index.G3](#), [index.S](#), [index.H](#), [index.KL](#), [index.Gap](#), [index.DB](#)

**Examples**

```
# Example 1
library(clusterSim)
data(data_ratio)
d <- dist.GDM(data_ratio)
c <- pam(d, 5, diss = TRUE)
icq <- index.G2(d,c$clustering)
print(icq)

# Example 2
library(clusterSim)
data(data_ordinal)
d <- dist.GDM(data_ordinal, method="GDM2")
# nc - number_of_clusters
min_nc=2
max_nc=6
res <- array(0,c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
clusters <- NULL
for (nc in min_nc:max_nc)
{
  cl2 <- pam(d, nc, diss=TRUE)
  res[nc-min_nc+1,2] <- G2 <- index.G2(d,cl2$cluster)
  clusters <- rbind(clusters,cl2$cluster)
}
print(paste("max G2 for", (min_nc:max_nc)[which.max(res[,2])], "clusters=", max(res[,2])))
print("clustering for max G2")
print(clusters[which.max(res[,2]),])
write.table(res, file="G2_res.csv", sep=";", dec=",", row.names=TRUE, col.names=FALSE)
plot(res, type="p", pch=0, xlab="Number of clusters", ylab="G2", xaxt="n")
axis(1, c(min_nc:max_nc))
```

---

index.G3

*Calculates G3 internal cluster quality index*

---

**Description**

Calculates G3 Hubert & Levine internal cluster quality index

**Usage**

```
index.G3(d,cl)
```

**Arguments**

d                    'dist' object  
c1                   A vector of integers indicating the cluster to which each object is allocated

**Details**

See file `\\$R\_HOME\library\clusterSim\pdf\indexG3\_details.pdf` for further details

**Value**

calculated G3 index

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**References**

Gatnar, E., Walesiak, M. (Eds.) (2004), *Metody statystycznej analizy wielowymiarowej w badaniach marketingowych [Multivariate statistical analysis methods in marketing research]*, Wydawnictwo AE, Wroclaw, p. 339. Available at: [http://keii.ue.wroc.pl/pracownicy/mw/2004\\_Gatnar\\_Walesiak\\_Metody\\_SAW\\_w\\_badaniach\\_marketingowych.pdf](http://keii.ue.wroc.pl/pracownicy/mw/2004_Gatnar_Walesiak_Metody_SAW_w_badaniach_marketingowych.pdf).  
Gordon, A.D. (1999), *Classification*, Chapman & Hall/CRC, London, p. 62. ISBN 9781584880134.  
Milligan, G.W., Cooper, M.C. (1985), *An examination of procedures of determining the number of cluster in a data set*, "Psychometrika", vol. 50, no. 2, 159-179. Available at: <https://dx.doi.org/10.1007/BF02294245>.

**See Also**

[index.G1](#), [index.G2](#), [index.S](#), [index.H](#), [index.KL](#), [index.Gap](#), [index.DB](#)

**Examples**

```
# Example 1
library(clusterSim)
data(data_ratio)
d <- dist.GDM(data_ratio)
c <- pam(d, 5, diss = TRUE)
icq <- index.G3(d,c$clustering)
print(icq)

# Example 2
library(clusterSim)
data(data_ordinal)
d <- dist.GDM(data_ordinal, method="GDM2")
# nc - number_of_clusters
min_nc=2
```

```

max_nc=6
res <- array(0,c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
clusters <- NULL
for (nc in min_nc:max_nc)
{
hc <- hclust(d, method="complete")
cl2 <- cutree(hc, k=nc)
res[nc-min_nc+1,2] <- G3 <- index.G3(d,cl2)
clusters <- rbind(clusters,cl2)
}
print(paste("min G3 for", (min_nc:max_nc)[which.min(res[,2])], "clusters=", min(res[,2])))
print("clustering for min G3")
print(clusters[which.min(res[,2]),])
write.table(res, file="G3_res.csv", sep=";", dec=".", row.names=TRUE, col.names=FALSE)
plot(res, type="p", pch=0, xlab="Number of clusters", ylab="G3", xaxt="n")
axis(1, c(min_nc:max_nc))

```

---

index.Gap

*Calculates Tibshirani, Walther and Hastie gap index*


---

### Description

Calculates Tibshirani, Walther and Hastie gap index

### Usage

```

index.Gap (x, clall, reference.distribution="unif", B=10,
method="pam", d=NULL, centrotypes="centroids")

```

### Arguments

x	data
clall	Two vectors of integers indicating the cluster to which each object is allocated in partition of n objects into u, and u+1 clusters
reference.distribution	"unif" - generate each reference variable uniformly over the range of the observed values for that variable or "pc" - generate the reference variables from a uniform distribution over a box aligned with the principal components of the data. In detail, if $X = \{x_{ij}\}$ is our $n \times m$ data matrix, assume that the columns have mean 0 and compute the singular value decomposition $X = UDV^T$ . We transform via $X' = XV$ and then draw uniform features $Z'$ over the ranges of the columns of $X'$ , as in method a) above. Finally we back-transform via $Z = Z'V^T$ to give reference data $Z$
B	the number of simulations used to compute the gap statistic
method	the cluster analysis method to be used. This should be one of: "ward.D", "ward.D2", "single", "complete", "average", "mcquitty", "median", "centroid", "pam", "k-means", "diana"

d optional distance matrix, used for calculations if centrotypes="medoids"  
centrotypes "centroids" or "medoids"

### Details

See file [../doc/indexGap\\_details.pdf](#) for further details

Thanks to dr Michael P. Fay from National Institute of Allergy and Infectious Diseases for finding "one column error".

### Value

Gap Tibshirani, Walther and Hastie gap index for u clusters  
diffu necessary value for choosing correct number of clusters via gap statistic  $\text{Gap}(u) - [\text{Gap}(u+1) - s(u+1)]$

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### References

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### See Also

[index.G1](#), [index.G2](#), [index.G3](#), [index.S](#), [index.H](#), [index.KL](#), [index.DB](#)

### Examples

```
# Example 1
library(clusterSim)
data(data_ratio)
cl1<-pam(data_ratio,4)
cl2<-pam(data_ratio,5)
clall<-cbind(cl1$clustering,cl2$clustering)
g<-index.Gap(data_ratio, clall, reference.distribution="unif", B=10,
  method="pam")
print(g)

# Example 2
library(clusterSim)
means <- matrix(c(0,2,4,0,3,6), 3, 2)
cov <- matrix(c(1,-0.9,-0.9,1), 2, 2)
x <- cluster.Gen(numObjects=40, means=means, cov=cov, model=2)
x <- x$data
md <- dist(x, method="euclidean")^2
```

```

# nc - number_of_clusters
min_nc=1
max_nc=5
min <- 0
clopt <- NULL
res <- array(0, c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
found <- FALSE
for (nc in min_nc:max_nc){
  cl1 <- pam(md, nc, diss=TRUE)
  cl2 <- pam(md, nc+1, diss=TRUE)
  clall <- cbind(cl1$clustering, cl2$clustering)
  gap <- index.Gap(x,clall,B=20,method="pam",centrotyes="centroids")
  res[nc-min_nc+1, 2] <- diffu <- gap$diffu
  if ((res[nc-min_nc+1, 2] >=0) && (!found)){
    nc1 <- nc
    min <- diffu
    clopt <- cl1$cluster
    found <- TRUE
  }
}
if (found){
print(paste("Minimal nc where diffu>=0 is",nc1,"for diffu=",round(min,4)),quote=FALSE)
}else{
print("I have not found clustering with diffu>=0", quote=FALSE)
}
plot(res,type="p",pch=0,xlab="Number of clusters",ylab="diffu",xaxt="n")
abline(h=0, untf=FALSE)
axis(1, c(min_nc:max_nc))

# Example 3
library(clusterSim)
means <- matrix(c(0,2,4,0,3,6), 3, 2)
cov <- matrix(c(1,-0.9,-0.9,1), 2, 2)
x <- cluster.Gen(numObjects=40, means=means, cov=cov, model=2)
x <- x$data
md <- dist(x, method="euclidean")^2
# nc - number_of_clusters
min_nc=1
max_nc=5
min <- 0
clopt <- NULL
res <- array(0, c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
found <- FALSE
for (nc in min_nc:max_nc){
  cl1 <- pam(md, nc, diss=TRUE)
  cl2 <- pam(md, nc+1, diss=TRUE)
  clall <- cbind(cl1$clustering, cl2$clustering)
  gap <- index.Gap(x,clall,B=20,method="pam",d=md,centrotyes="medoids")
  res[nc-min_nc+1, 2] <- diffu <- gap$diffu
  if ((res[nc-min_nc+1, 2] >=0) && (!found)){
    nc1 <- nc

```



```

    min <- diffu
    clopt <- cl1$cluster
    found <- TRUE
  }
}
if (found){
print(paste("Minimal nc where diffu>=0 is",nc1,"for diffu=",round(min,4)),quote=FALSE)
}else{
print("I have not found clustering with diffu>=0",quote=FALSE)
}
plot(res, type="p", pch=0, xlab="Number of clusters", ylab="diffu", xaxt="n")
abline(h=0, untf=FALSE)
axis(1, c(min_nc:max_nc))

```

---

index.H

*Calculates Hartigan index*


---

### Description

Calculates Hartigan index

### Usage

```
index.H (x, clall, d=NULL, centrotypes="centroids")
```

### Arguments

x	data
clall	Two vectors of integers indicating the cluster to which each object is allocated in partition of n objects into u and u+1 clusters
d	optional distance matrix, used for calculations if centrotypes="medoids"
centrotypes	"centroids" or "medoids"

### Details

See file `\$R\_HOME\library\clusterSim\pdf\indexH\_details.pdf` for further details

### Value

Hartigan index

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## References

- Hartigan, J. (1975), *Clustering algorithms*, Wiley, New York. ISBN 047135645X.
- Milligan, G.W., Cooper, M.C. (1985), *An examination of procedures of determining the number of cluster in a data set*, "Psychometrika", vol. 50, no. 2, 159-179. Available at: <https://dx.doi.org/10.1007/BF02294245>.
- Tibshirani, R., Walther, G., Hastie, T. (2001), *Estimating the number of clusters in a data set via the gap statistic*, "Journal of the Royal Statistical Society", ser. B, vol. 63, part 2, 411-423. Available at: <http://dx.doi.org/10.1111/1467-9868.00293>.

## See Also

[index.G1](#), [index.G2](#), [index.G3](#), [index.S](#), [index.KL](#), [index.Gap](#), [index.DB](#)

## Examples

```
# Example 1
library(clusterSim)
data(data_ratio)
cl1<-pam(data_ratio,4)
cl2<-pam(data_ratio,5)
clall<-cbind(cl1$clustering,cl2$clustering)
index.H(data_ratio,clall)

# Example 2
library(clusterSim)
data(data_ratio)
md <- dist(data_ratio, method="euclidean")
# nc - number_of_clusters
min_nc=1
max_nc=20
min <- 0
res <- array(0, c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
found <- FALSE
clusters <- NULL
for (nc in min_nc:max_nc)
{
  print(nc)
  hc <- hclust(md, method="complete")
  cl1 <- cutree(hc, k=nc)
  cl2 <- cutree(hc, k=nc+1)
  clall <- cbind(cl1,cl2)
  res[nc-min_nc+1,2] <- H <- index.H(data_ratio,clall,centrotypes="centroids")
  if ((res[nc-min_nc+1, 2]<10) && (!found)){
    nc1 <- nc
    min <- H
    clopt <- cl1
    found <- TRUE
  }
}
if (found)
```

```

{
print(paste("minimal nc for H<=10 equals",nc1,"for H=",min))
print("clustering for minimal nc where H<=10")
print(clopt)
}else
{
print("Clustering not found with H<=10")
}
write.table(res,file="H_res.csv",sep=";",dec=",",row.names=TRUE,col.names=FALSE)
plot(res,type="p",pch=0,xlab="Number of clusters",ylab="H",xaxt="n")
abline(h=10, untf=FALSE)
axis(1, c(min_nc:max_nc))

# Example 3
library(clusterSim)
data(data_ratio)
md <- dist(data_ratio, method="manhattan")
# nc - number_of_clusters
min_nc=1
max_nc=20
min <- 0
res <- array(0, c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
found <- FALSE
clusters <- NULL
for (nc in min_nc:max_nc)
{
print(nc)
hc <- hclust(md, method="complete")
cl1 <- cutree(hc, k=nc)
cl2 <- cutree(hc, k=nc+1)
clall <- cbind(cl1,cl2)
res[nc-min_nc+1,2] <- H <- index.H(data_ratio,clall,d=md,centrotypes="medoids")
if ((res[nc-min_nc+1, 2]<10) && (!found)){
nc1 <- nc
min <- H
clopt <- cl1
found <- TRUE
}
}
if (found)
{
print(paste("minimal nc for H<=10 equals",nc1,"for H=",min))
print("clustering for minimal nc where H<=10")
print(clopt)
}else
{
print("Clustering not found with H<=10")
}
write.table(res,file="H_res.csv",sep=";",dec=",",row.names=TRUE,col.names=FALSE)
plot(res,type="p",pch=0,xlab="Number of clusters",ylab="H",xaxt="n")
abline(h=10, untf=FALSE)
axis(1, c(min_nc:max_nc))

```

---

index.KL	<i>Calculates Krzanowski-Lai index</i>
----------	--

---

### Description

Calculates Krzanowski-Lai index

### Usage

```
index.KL (x,clall,d=NULL,centrotypes="centroids")
```

### Arguments

x	data
clall	Three vectors of integers indicating the cluster to which each object is allocated in partition of n objects into u-1, u, and u+1 clusters
d	optional distance matrix, used for calculations if centrotypes="medoids"
centrotypes	"centroids" or "medoids"

### Details

See file [../doc/indexKL\\_details.pdf](#) for further details

### Value

Krzanowski-Lai index

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### References

- Krzanowski, W.J., Lai, Y.T. (1988), *A criterion for determining the number of groups in a data set using sum of squares clustering*, "Biometrics", 44, 23-34. Available at: <http://dx.doi.org/10.2307/2531893>.
- Milligan, G.W., Cooper, M.C. (1985), *An examination of procedures of determining the number of cluster in a data set*, "Psychometrika", vol. 50, no. 2, 159-179. Available at: <https://dx.doi.org/10.1007/BF02294245>.
- Tibshirani, R., Walther, G., Hastie, T. (2001), *Estimating the number of clusters in a data set via the gap statistic*, "Journal of the Royal Statistical Society", ser. B, vol. 63, part 2, 411-423. Available at: <http://dx.doi.org/10.1111/1467-9868.00293>.

**See Also**

[index.G1](#), [index.G2](#), [index.G3](#), [index.S](#), [index.H](#), [index.Gap](#), [index.DB](#)

**Examples**

```
# Example 1
library(clusterSim)
data(data_ratio)
cl1<-pam(data_ratio,4)
cl2<-pam(data_ratio,5)
cl3<-pam(data_ratio,6)
clall<-cbind(cl1$clustering,cl2$clustering,cl3$clustering)
index.KL(data_ratio,clall)

# Example 2
library(clusterSim)
data(data_ratio)
md <- dist(data_ratio, method="manhattan")
# nc - number_of_clusters
min_nc=2
max_nc=15
res <- array(0, c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
clusters <- NULL
for (nc in min_nc:max_nc)
{
  if(nc-1==1){
    clustering1<-rep(1,nrow(data_ratio))
  }
  else{
    clustering1 <- pam(md, nc-1, diss=TRUE)$clustering
  }
  clustering2 <- pam(md, nc, diss=TRUE)$clustering
  clustering3 <- pam(md, nc+1, diss=TRUE)$clustering
  clall<- cbind(clustering1, clustering2, clustering3)
  res[nc-min_nc+1,2] <- KL <- index.KL(data_ratio,clall,centrotypes="centroids")
  clusters <- rbind(clusters, clustering2)
}
print(paste("max KL for", (min_nc:max_nc)[which.max(res[,2])], "clusters=", max(res[,2])))
print("clustering for max KL")
print(clusters[which.max(res[,2]),])
write.table(res, file="KL_res.csv", sep=";", dec=".", row.names=TRUE, col.names=FALSE)
plot(res, type="p", pch=0, xlab="Number of clusters", ylab="KL", xaxt="n")
axis(1, c(min_nc:max_nc))

# Example 3
library(clusterSim)
data(data_ratio)
md <- dist(data_ratio, method="manhattan")
# nc - number_of_clusters
min_nc=2
max_nc=15
```

```

res <- array(0, c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
clusters <- NULL
for (nc in min_nc:max_nc)
{
  if(nc-1==1){
    clustering1<-rep(1,nrow(data_ratio))
  }
  else{
    clustering1 <- pam(md, nc-1, diss=TRUE)$clustering
  }
  clustering2 <- pam(md, nc, diss=TRUE)$clustering
  clustering3 <- pam(md, nc+1, diss=TRUE)$clustering
  clall<- cbind(clustering1, clustering2, clustering3)
  res[nc-min_nc+1,2] <- KL <- index.KL(data_ratio,clall,d=md,centrotyes="medoids")
  clusters <- rbind(clusters, clustering2)
}
print(paste("max KL for", (min_nc:max_nc)[which.max(res[,2])], "clusters=", max(res[,2])))
print("clustering for max KL")
print(clusters[which.max(res[,2]),])
write.table(res, file="KL_res.csv", sep=";", dec=".", row.names=TRUE, col.names=FALSE)
plot(res, type="p", pch=0, xlab="Number of clusters", ylab="KL", xaxt="n")
axis(1, c(min_nc:max_nc))

```

---

index.S

*Calculates Rousseeuw's Silhouette internal cluster quality index*


---

### Description

Calculates Rousseeuw's Silhouette internal cluster quality index

### Usage

```
index.S(d,cl,singleObject=0)
```

### Arguments

d	'dist' object
cl	A vector of integers indicating the cluster to which each object is allocated
singleObject	0 - $s(i)=0$ or 1 - $s(i)=1$ . When cluster contains a single object, it is unclear how $a(i)$ of Silhouette index should be defined (see Kaufman & Rousseeuw (1990), p. 85).

### Details

See file `\$R\_HOME\library\clusterSim\pdf\indexS\_details.pdf` for further details

### Value

calculated Silhouette index

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**References**

Gatnar, E., Walesiak, M. (Eds.) (2004), *Metody statystycznej analizy wielowymiarowej w badaniach marketingowych [Multivariate statistical analysis methods in marketing research]*, Wydawnictwo AE, Wrocław, 342-343, erratum. Available at: [http://keii.ue.wroc.pl/pracownicy/mw/2004\\_Gatnar\\_Walesiak\\_Metody\\_SAW\\_w\\_badaniach\\_marketingowych.pdf](http://keii.ue.wroc.pl/pracownicy/mw/2004_Gatnar_Walesiak_Metody_SAW_w_badaniach_marketingowych.pdf).

Kaufman, L., Rousseeuw, P.J. (1990), *Finding groups in data: an introduction to cluster analysis*, Wiley, New York, pp. 83-88. ISBN: 978-0-471-73578-6.

**See Also**

[index.G1](#), [index.G2](#), [index.G3](#), [index.KL](#), [index.H](#), [index.Gap](#), [index.DB](#)

**Examples**

```
# Example 1
library(clusterSim)
data(data_ratio)
d <- dist.GDM(data_ratio)
c <- pam(d, 5, diss = TRUE)
icq <- index.S(d,c$clustering)
print(icq)

# Example 2
library(clusterSim)
data(data_ratio)
md <- dist(data_ratio, method="manhattan")
# nc - number_of_clusters
min_nc=2
max_nc=20
res <- array(0, c(max_nc-min_nc+1, 2))
res[,1] <- min_nc:max_nc
clusters <- NULL
for (nc in min_nc:max_nc)
{
  cl2 <- pam(md, nc, diss=TRUE)
  res[nc-min_nc+1, 2] <- S <- index.S(md,cl2$cluster)
  clusters <- rbind(clusters, cl2$cluster)
}
print(paste("max S for", (min_nc:max_nc)[which.max(res[,2])], "clusters=", max(res[,2])))
print("clustering for max S")
print(clusters[which.max(res[,2]),])
write.table(res, file="S_res.csv", sep=";", dec=".", row.names=TRUE, col.names=FALSE)
plot(res, type="p", pch=0, xlab="Number of clusters", ylab="S", xaxt="n")
axis(1, c(min_nc:max_nc))
```

initial.Centers

*Calculation of initial clusters centers for k-means like algorithms***Description**

Function calculates initial clusters centers for k-means like algorithms with the following algorithm (similar to SPSS QuickCluster function)

(a) if the distance between  $x_k$  and its closest cluster center is greater than the distance between the two closest centers ( $M_m$  and  $M_n$ ), then  $x_k$  replaces either  $M_m$  or  $M_n$ , whichever is closer to  $x_k$ .

(b) If  $x_k$  does not replace a cluster initial center in (a), a second test is made: If that distance  $d_q$  greater than the distance between  $M_q$  and its closest  $M_i$ , then  $x_k$  replaces  $M_q$ .

where:

$M_i$  - initial center of  $i$ -th cluster

$x_k$  - vector of  $k$ -th observation

$d(\dots, \dots)$  - Euclidean distance

$d_{mn} = \min_{ij} d(M_i, M_j)$

$d_q = \min_i d(x_k, M_i)$

**Usage**

`initial.Centers(x, k)`

**Arguments**

x	matrix or dataset
k	number of initial cluster centers

**Value**

Numbers of objects chosen as initial cluster centers

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<http://keii.ue.wroc.pl/clusterSim>

**References**

Hartigan, J. (1975), *Clustering algorithms*, Wiley, New York. ISBN 0-471-35645-X.

**See Also**

[cluster.Sim](#)



**Examples**

```
#Example 1 (numbers of objects choosen as initial cluster centers)
library(clusterSim)
data(data_ratio)
ic <- initial.Centers(data_ratio, 10)
print(ic)

#Example 2 (application with kmeans algorithm)
library(clusterSim)
data(data_ratio)
kmeans(data_ratio,data_ratio[initial.Centers(data_ratio, 10),])
```

---

```
interval_normalization
```

*Types of normalization formulas for interval-valued symbolic variables*

---

**Description**

Types of normalization formulas for interval-valued symbolic variables

**Usage**

```
interval_normalization(x,dataType="simple", type="n0",y=NULL)
```

**Arguments**

x	matrix dataset or symbolic table object
dataType	Type of symbolic data table passed to function, 'sda' - full symbolicDA format object; 'simple' - three dimensional array with lower and upper bound of intervals in third dimension; 'separate_tables' - lower bounds of intervals in x, upper bounds in y; 'rows' - lower and upper bound of intervals in neighbouring rows; 'columns' - lower and upper bound of intervals in neighbouring columns
type	type of normalization: n0 - without normalization n1 - standardization $((x-\text{mean})/\text{sd})$ n2 - positional standardization $((x-\text{median})/\text{mad})$ n3 - unitization $((x-\text{mean})/\text{range})$ n3a - positional unitization $((x-\text{median})/\text{range})$ n4 - unitization with zero minimum $((x-\text{min})/\text{range})$ n5 - normalization in range $<-1,1>$ $((x-\text{mean})/\text{max}(\text{abs}(x-\text{mean})))$ n5a - positional normalization in range $<-1,1>$ $((x-\text{median})/\text{max}(\text{abs}(x-\text{median})))$ n6 - quotient transformation $(x/\text{sd})$

n6a	- positional quotient transformation ( $x/\text{mad}$ )
n7	- quotient transformation ( $x/\text{range}$ )
n8	- quotient transformation ( $x/\text{max}$ )
n9	- quotient transformation ( $x/\text{mean}$ )
n9a	- positional quotient transformation ( $x/\text{median}$ )
n10	- quotient transformation ( $x/\text{sum}$ )
n11	- quotient transformation ( $x/\text{sqrt(SSQ)}$ )
n12	- normalization ( $((x-\text{mean})/\text{sqrt}(\text{sum}((x-\text{mean})^2)))$ )
n12a	- positional normalization ( $((x-\text{median})/\text{sqrt}(\text{sum}((x-\text{median})^2)))$ )
n13	- normalization with zero being the central point ( $((x-\text{midrange})/(\text{range}/2))$ )
y	matrix or dataset with upper bounds of intervals if argument <code>dataType</code> is <code>uuqual</code> to <code>"separate_tables"</code>

**Value**

Normalized data

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**References**

Jajuga, K., Walesiak, M. (2000), *Standardisation of data set under different measurement scales*, In: R. Decker, W. Gaul (Eds.), *Classification and information processing at the turn of the millennium*, Springer-Verlag, Berlin, Heidelberg, 105-112. Available at: [http://dx.doi.org/10.1007/978-3-642-57280-7\\_11](http://dx.doi.org/10.1007/978-3-642-57280-7_11).

Milligan, G.W., Cooper, M.C. (1988), *A study of standardization of variables in cluster analysis*, "Journal of Classification", vol. 5, 181-204. Available at: <https://dx.doi.org/10.1007/BF01897163>.

Walesiak, M. (2014), *Przegląd formuł normalizacji wartości zmiennych oraz ich własności w statystycznej analizie wielowymiarowej [Data normalization in multivariate data analysis. An overview and properties]*, "Przegląd Statystyczny" ("Statistical Review"), vol. 61, no. 4, 363-372. Available at: [http://keii.ue.wroc.pl/pracownicy/mw/2014\\_Walesiak\\_Przeglad\\_Statystyczny\\_z\\_4.pdf](http://keii.ue.wroc.pl/pracownicy/mw/2014_Walesiak_Przeglad_Statystyczny_z_4.pdf).

Walesiak, M., Dudek, A. (2017), *Selecting the Optimal Multidimensional Scaling Procedure for Metric Data with R Environment*, „STATISTICS IN TRANSITION new series”, September, Vol. 18, No. 3, pp. 521-540. Available at: <http://stat.gov.pl/en/sit-en/issues-and-articles-sit/>.

**See Also**

[data.Normalization](#)

## Examples

```
library(clusterSim)
data(data_symbolic_interval_polish_voivodships)
n<-interval_normalization(data_symbolic_interval_polish_voivodships,dataType="simple",type="n2")
plotInterval(n$simple)
```

---

ordinalToMetric

*Reinforcing measurement scale for ordinal data*

---

## Description

Reinforcing measurement scale for ordinal data (ordinal to metric scale)

## Usage

```
ordinalToMetric(data,scaleType="o",patternCoordinates)
```

## Arguments

data	matrix or dataset
scaleType	"o" - variables measured on ordinal scale, "m" - variables measured on metric scale, "o/m" - vector with mixed variables - e.g. c("o","m","m","o","o","m")
patternCoordinates	vector containing pattern coordinates c(...) given by the reaseracher for data (for metric variables - NA, for ordinal variables - one of the categories for each ordinal variable (e.g. maximum category))

## Details

See file [../doc/ordinalToMetric\\_details.pdf](#) for further details

## Value

pdata	raw (primary) data matrix
tdata	data matrix after transformation of ordinal variables into metric variables
cpattern	vector containing pattern coordinates

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<http://keii.ue.wroc.pl/clusterSim>

## References

Jajuga, K., Walesiak, M., Bak, A. (2003), *On the general distance measure*, In: M. Schwaiger, O. Opitz (Eds.), *Exploratory data analysis in empirical research*, Springer-Verlag, Berlin, Heidelberg, 104-109. Available at: [http://dx.doi.org/10.1007/978-3-642-55721-7\\_12](http://dx.doi.org/10.1007/978-3-642-55721-7_12).

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## See Also

[dist.GDM](#)

## Examples

```
# Example 1
library(clusterSim)
data(data_patternGDM2)
res1<-ordinalToMetric(data_patternGDM2, scaleType="o", patternCoordinates=c(5,4,3,1,1,3))
print(res1)
```

```
# Example 2
library(clusterSim)
data(data_patternGDM2)
res2<-ordinalToMetric(data_patternGDM2, scaleType="o", patternCoordinates=c(5,4,3,4,2,4))
print(res2)
```

---

pattern.GDM1

*An application of GDM1 distance for metric data to compute the distances of objects from the pattern object (upper or lower)*

---

**Description**

An application of GDM1 distance for metric data to compute the distances of objects from the upper (ideal point co-ordinates) or lower (anti-ideal point co-ordinates) pattern object

**Usage**

```
pattern.GDM1(data, performanceVariable, scaleType="i",
nomOptValues=NULL, weightsType="equal", weights=NULL,
normalization="n0", patternType="upper",
patternCoordinates="dataBounds", patternManual=NULL,
nominalTransfMethod=NULL)
```

**Arguments**

data	matrix or dataset
performanceVariable	vector containing three types of performance variables: s for stimulants where higher value means better performance d for destimulants where low values indicate better performance n for nominants where the best value is implied. Object performance is positively assessed if the measure has implied value
scaleType	"i" - variables measured on interval scale, "r" - variables measured on ratio scale, "r/i" - vector with mixed variables
nomOptValues	vector containing optimal values for nominant variables and NA values for stimulants and destimulants. If performanceVariable do not contain nominant variables this nomOptValues may be set to NULL
weightsType	equal or different1 or different2 "equal" - equal weights "different1" - vector of different weights should satisfy conditions: each weight takes value from interval [0; 1] and sum of weights equals one "different2" - vector of different weights should satisfy conditions: each weight takes value from interval [0; m] and sum of weights equals m (m - the number of variables)
normalization	normalization formulas as in data.Normalization function
weights	vector of weights
patternType	"upper" - ideal point co-ordinates consists of the best variables' values "lower" - anti-ideal point co-ordinates consists of the worst variables' values
patternCoordinates	"dataBounds" - pattern should be calculated as following: "upper" pattern (maximum for stimulants, minimum for destimulants), "lower" pattern (minimum for stimulants, maximum for destimulants) "manual" - pattern should be given in patternManual variable
patternManual	Pattern co-ordinates contain: real numbers "min" - for minimal value of variable "max" - for maximal value of variable

nominalTransfMethod

method of transformation of nominant to stimulant variable:

"q" - quotient transformation

"d" - difference transformation

## Details

See file [../doc/patternGDM1\\_details.pdf](#) for further details

## Value

pdata	raw (primary) data matrix
tdata	data matrix after transformation of nominant variables (with pattern in last row)
data	data matrix after normalization (with pattern in last row)
distances	GDM1 distances from pattern object
sortedDistances	sorted GDM1 distances from pattern object

## Author(s)

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**See Also**

[dist.GDM,data.Normalization](#)

**Examples**

```
# Example 1
library(clusterSim)
data(data_patternGDM1)
res<-pattern.GDM1(data_patternGDM1,
performanceVariable=c("s","s","s","s","s","s","d","d","s","s"),
scaleType="r",nomOptValues=NULL,weightsType<-"equal",weights=NULL,
normalization<-"n4",patternType<-"lower",patternCoordinates<-"manual",
patternManual<-c("min","min","min","min","min","min","max","max","min","min"),
nominalTransfMethod <-NULL)
print(res)
gdm_p<-res$distances
plot(cbind(gdm_p,gdm_p),xlim=c(max(gdm_p),min(gdm_p)),
ylim=c(min(gdm_p),max(gdm_p)),xaxt="n",
xlab="Order of objects from the best to the worst",
ylab="GDM distances from pattern object", lwd=1.6)
axis(1, at=gdm_p,labels=names(gdm_p), cex.axis=0.5)
```

```
# Example 2
library(clusterSim)
data(data_patternGDM1)
res<-pattern.GDM1(data_patternGDM1,
performanceVariable=c("s","s","s","s","s","s","d","d","s","s"),
scaleType="r",nomOptValues=NULL,weightsType<-"equal",weights=NULL,
normalization<-"n2",patternType<-"upper",
patternCoordinates<-"dataBounds",patternManual<-NULL,
nominalTransfMethod<-NULL)
print(res)
gdm_p<-res$distances
plot(cbind(gdm_p,gdm_p),xlim=c(min(gdm_p),max(gdm_p)),
ylim=c(min(gdm_p),max(gdm_p)),xaxt="n",
xlab="Order of objects from the best to the worst",
ylab="GDM distances from pattern object", lwd=1.6)
axis(1, at=gdm_p,labels=names(gdm_p), cex.axis=0.5)
```

```
# Example 3
library(clusterSim)
data(data_patternGDM1)
res<-pattern.GDM1(data_patternGDM1,
performanceVariable=c("s","s","s","s","s","s","d","d","s","s"),
scaleType="r",nomOptValues=NULL,weightsType<-"different2",
weights=c(1.1,1.15,1.15,1.1,1.1,0.7,0.7,1.2,0.8,1.0),
normalization<-"n6",patternType<-"upper",patternCoordinates<-"manual",
patternManual<-c(100,100,100,100,100,"max","min","min","max","max"),
nominalTransfMethod <-NULL)
print(res)
gdm_p<-res$distances
plot(cbind(gdm_p,gdm_p),xlim=c(min(gdm_p),max(gdm_p)),
```

```
ylim=c(min(gdm_p),max(gdm_p)),xaxt="n",
xlab="Order of objects from the best to the worst",
ylab="GDM distances from pattern object", lwd=1.6)
axis(1, at=gdm_p,labels=names(gdm_p), cex.axis=0.5)
```

---

pattern.GDM2	<i>An application of GDM2 distance for ordinal data to compute the distances of objects from the pattern object (upper or lower)</i>
--------------	--

---

### Description

An application of GDM2 distance for ordinal data to compute the distances of objects from the upper (ideal point co-ordinates) or lower (anti-ideal point co-ordinates) pattern object

### Usage

```
pattern.GDM2(data, performanceVariable, nomOptValues=NULL,
weightsType="equal", weights=NULL, patternType="upper",
patternCoordinates="dataBounds", patternManual=NULL,
nominalTransfMethod=NULL)
```

### Arguments

data	matrix or dataset
performanceVariable	vector containing three types of performance variables: s for stimulants where higher value means better performance d for destimulants where low values indicate better performance n for nominants where the best value is implied. Object performance is positively assessed if the measure has implied value
nomOptValues	vector containing optimal values for nominant variables and NA values for stimulants and destimulants. If performanceVariable do not contain nominant variables this nomOptValues may be set to NULL
weightsType	equal or different1 or different2 "equal" - equal weights "different1" - vector of different weights should satisfy conditions: each weight takes value from interval [0; 1] and sum of weights equals one "different2" - vector of different weights should satisfy conditions: each weight takes value from interval [0; m] and sum of weights equals m (m - the number of variables)
weights	vector of weights
patternType	"upper" - ideal point co-ordinates consists of the best variables' values "lower" - anti-ideal point co-ordinates consists of the worst variables' values



patternCoordinates	"dataBounds" - pattern should be calculated as following: "upper" pattern (maximum for stimulants, minimum for destimulants, nominal value for nominants), "lower" pattern (minimum for stimulants, maximum for destimulants) "manual" - pattern should be given in patternManual variable
patternManual	Pattern co-ordinates contain: real numbers "min" - for minimal value of variable "max" - for maximal value of variable "nom" - for nominal value of variable (for upper pattern only - given in nomOptValues vector)
nominalTransfMethod	method of transformation of nominant to destimulant variable for patternType="lower": "database" - for each nominant separately GDM2 distance is calculated between each nominant observation (with repetitions - all variable values are used in calculation) and nominal value. Next the variable observations are replaced by those distances "symmetrical" - for each nominant separately GDM2 distance is calculated between each nominant observation (without repetition - each observation is used once) and nominal value. Next the variable observations are replaced by those distances

### Details

See file [../doc/patternGDM2\\_details.pdf](#) for further details

### Value

pdata	raw (primary) data matrix
data	data matrix after transformation of nominant variables (with pattern in last row)
distances	GDM2 distances from pattern object
sortedDistances	sorted GDM2 distances from pattern object

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## See Also

[dist.GDM](#)

## Examples

```
# Example 1
library(clusterSim)
data(data_patternGDM2)
res<-pattern.GDM2(data_patternGDM2,
performanceVariable=c("s","s","s","d","d","n"),
nomOptValues=c(NA,NA,NA,NA,NA,3), weightsType<-"equal", weights=NULL,
patternType="lower", patternCoordinates="manual",
patternManual=c("min","min",0,5,"max","max"),
nominalTransfMethod="symmetrical")
print(res)
gdm_p<-res$distances
plot(cbind(gdm_p,gdm_p),xlim=c(max(gdm_p),min(gdm_p)),
ylim=c(min(gdm_p),max(gdm_p)),
xaxt="n",xlab="Order of objects from the best to the worst",
ylab="GDM distances from pattern object", lwd=1.6)
axis(1, at=gdm_p,labels=names(gdm_p), cex.axis=0.5)
```

```
# Example 2
library(clusterSim)
data(data_patternGDM2)
res<-pattern.GDM2(data_patternGDM2,
performanceVariable=c("s","s","s","d","d","n"),
nomOptValues=c(NA,NA,NA,NA,NA,3), weightsType<-"equal", weights=NULL,
patternType="upper", patternCoordinates="dataBounds",
```

```

patternManual=NULL, nominalTransfMethod="database")
print(res)
gdm_p<-res$distances
plot(cbind(gdm_p,gdm_p), xlim=c(min(gdm_p),max(gdm_p)),
ylim=c(min(gdm_p),max(gdm_p)),
xaxt="n",xlab="Order of objects from the best to the worst",
ylab="GDM distances from pattern object", lwd=1.6)
axis(1, at=gdm_p,labels=names(gdm_p), cex.axis=0.5)

```

---

plotCategorical	<i>Plot categorical data on a scatterplot matrix</i>
-----------------	--

---

### Description

Plot categorical data on a scatterplot matrix (optionally with clusters)

### Usage

```
plotCategorical(x, pairsofVar=NULL, cl=NULL, clColors=NULL,...)
```

### Arguments

x	data matrix (rows correspond to observations and columns correspond to variables)
pairsofVar	pairs of variables - all variables (pairsofVar=NULL) or selected variables, e.g. pairsofVar=c(1,3,4)
cl	cluster membership vector
clColors	The colors of clusters. The colors are given arbitrary (clColors=TRUE) or by hand, e.g. clColors=c("red", "blue", "green"). The number of colors equals the number of clusters
...	Arguments to be passed to methods, such as graphical parameters (see <a href="#">par</a> ).

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### See Also

[plotCategorical3d](#), [colors](#), [pairs](#)

**Examples**

```
# Example 1
library(clusterSim)
data(data_ordinal)
plotCategorical(data_ordinal, pairsofVar=c(1,3,4,9), cl=NULL,
clColors = NULL)

# Example 2
library(clusterSim)
grnd <- cluster.Gen(50,model=5,dataType="o",numCategories=5)
plotCategorical(grnd$data, pairsofVar=NULL, cl=grnd$clusters,
clColors=TRUE)

# Example 3
library(clusterSim)
grnd<-cluster.Gen(50,model=4,dataType="o",numCategories=7, numNoisyVar=2)
plotCategorical(grnd$data, pairsofVar=NULL, cl=grnd$clusters,
clColors = c("red","blue","green"))
```

---

plotCategorical3d

*Plot categorical data with three-dimensional plots*


---

**Description**

Plot categorical data with three-dimensional plots (optionally with clusters)

**Usage**

```
plotCategorical3d(x, tripleofVar=c(1,2,3), cl=NULL, clColors=NULL,...)
```

**Arguments**

x	data matrix (rows correspond to observations and columns correspond to variables)
tripleofVar	triple of variables - vector of the number of variables, e.g. tripleofVar = c(1, 3, 4)
cl	cluster membership vector
clColors	The colors of clusters. The colors are given arbitrary (clColors=TRUE) or by hand, e.g. clColors=c("red", "blue", "green"). The number of colors equals the number of clusters
...	Arguments to be passed to methods, such as graphical parameters (see <a href="#">par</a> ).

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**See Also**[plotCategorical.colors](#)**Examples**

```
# These examples do not run on Mac_OS-X. We're working to fix them
# They run quite well on Windows and Linux in meantime

# Example 1
#library(clusterSim)
#data(data_ordinal)
#plotCategorical3d(data_ordinal, tripleofVar=c(1,3,9), cl=NULL,
#clColors=NULL)

# Example 2
#library(clusterSim)
#grnd <- cluster.Gen(50,model=5,dataType="o",numCategories=5)
#plotCategorical3d(grnd$data, tripleofVar=c(1,2,3), cl=grnd$clusters,
#clColors=TRUE)

# Example 3
#library(clusterSim)
#grnd <- cluster.Gen(50, model=4, dataType="o", numCategories=7, numNoisyVar=2)
#plotCategorical3d(grnd$data, tripleofVar=c(1,2,4), cl=grnd$clusters,
#clColors=c("red", "blue", "green"))
```

plotInterval

*Plot symbolic interval-valued data on a scatterplot matrix***Description**

Plot symbolic interval-valued data on a scatterplot matrix (optionally with clusters)

**Usage**

```
plotInterval(x, pairsofsVar=NULL, cl=NULL, clColors=NULL,...)
```

**Arguments**

x	symbolic interval-valued data
pairsofsVar	pairs of symbolic interval variables - all variables (pairsofsVar=NULL) or selected variables, e.g. pairsofsVar=c(1,3,4)
cl	cluster membership vector
clColors	The colors of clusters. The colors are given arbitrary (clColors=TRUE) or by hand, e.g. clColors=c("red", "blue", "green"). The number of colors equals the number of clusters
...	Arguments to be passed to methods, such as graphical parameters (see <a href="#">par</a> ).

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**See Also**

[plotCategorical](#), [plotCategorical3d](#), [colors](#), [pairs](#)

**Examples**

```
# Example 1
library(clusterSim)
data(data_symbolic)
plotInterval(data_symbolic, pairsofsVar=c(1,3,4,6), cl=NULL,
             clColors=NULL)

# Example 2
library(clusterSim)
grnd <- cluster.Gen(60, model=5, dataType="s", numNoisyVar=1,
                  numOutliers=10, rangeOutliers=c(1,5))
grnd$clusters[grnd$clusters==0] <- max(grnd$clusters)+1
# To colour outliers
plotInterval(grnd$data, pairsofsVar=NULL, cl=grnd$clusters,
             clColors=TRUE)

# Example 3
library(clusterSim)
grnd <- cluster.Gen(50, model=4, dataType="s", numNoisyVar=2,
                  numOutliers=10, rangeOutliers=c(1,4))
grnd$clusters[grnd$clusters==0] <- max(grnd$clusters)+1
# To colour outliers
plotInterval(grnd$data, pairsofsVar=NULL, cl=grnd$clusters,
             clColors=c("red", "blue", "green", "yellow"))
```

---

replication.Mod

*Modification of replication analysis for cluster validation*

---

**Description**

Modification of replication analysis for cluster validation

**Usage**

```
replication.Mod(x, v="m", u=2, centrotypes="centroids",
               normalization=NULL, distance=NULL, method="kmeans",
               S=10, fixedAsample=NULL)
```

**Arguments**

x	data matrix
v	type of data: metric ("r" - ratio, "i" - interval, "m" - mixed), nonmetric ("o" - ordinal, "n" - multi-state nominal, "b" - binary)
u	number of clusters given arbitrary
centrotypes	"centroids" or "medoids"
normalization	optional, normalization formulas for metric data (normalization by variable): for ratio data: "n0" - without normalization, "n6" - (x/sd), "n6a" - (x/mad), "n7" - (x/range), "n8" - (x/max), "n9" - (x/mean), "n9a" - (x/median), "n10" - (x/sum), "n11" - x/sqrt(SSQ) for interval or mixed data: "n0" - without normalization, "n1" - (x-mean)/sd, "n2" - (x-median)/mad, "n3" - (x-mean)/range, "n3a" - positional unitization (x-median)/range, "n4" - (x-min)/range, "n5" - (x-mean)/max[abs(x-mean)], "n5a" - (x-median)/max[abs(x-median)], "n12" - normalization (x - mean)/(sum(x - mean)^2)^0.5, "n12a" - positional normalization (x - median)/(sum(x - median)^2)^0.5, "n13" - normalization with zero being the central point ((x-midrange)/(range/2))
distance	distance measures NULL for "kmeans" method (based on data matrix), for ratio data: "d1" - Manhattan, "d2" - Euclidean, "d3" - Chebychev (max), "d4" - squared Euclidean, "d5" - GDM1, "d6" - Canberra, "d7" - Bray-Curtis for interval or mixed (ratio & interval) data: "d1", "d2", "d3", "d4", "d5" for ordinal data: "d8" - GDM2 for multi-state nominal: "d9" - Sokal & Michener for binary data: "b1" = Jaccard; "b2" = Sokal & Michener; "b3" = Sokal & Sneath (1); "b4" = Rogers & Tanimoto; "b5" = Czekanowski; "b6" = Gower & Legendre (1); "b7" = Ochiai; "b8" = Sokal & Sneath (2); "b9" = Phi of Pearson; "b10" = Gower & Legendre (2)
method	clustering method: "kmeans" (default), "single", "complete", "average", "mcquitty", "median", "centroid", "ward.D", "ward.D2", "pam", "diana"
S	the number of simulations used to compute mean corrected Rand index
fixedAsample	if NULL A sample is generated randomly, otherwise this parameter contains object numbers arbitrarily assigned to A sample

**Details**

See file [../doc/replication.Mod\\_details.pdf](#) for further details

**Value**

A	3-dimensional array containing data matrices for A sample of objects in each simulation (first dimension represents simulation number, second - object number, third - variable number)
B	3-dimensional array containing data matrices for B sample of objects in each simulation (first dimension represents simulation number, second - object number, third - variable number)

centroid	3-dimensional array containing centroids of u clusters for A sample of objects in each simulation (first dimension represents simulation number, second - cluster number, third - variable number)
medoid	3-dimensional array containing matrices of observations on u representative objects (medoids) for A sample of objects in each simulation (first dimension represents simulation number, second - cluster number, third - variable number)
clusteringA	2-dimensional array containing cluster numbers for A sample of objects in each simulation (first dimension represents simulation number, second - object number)
clusteringB	2-dimensional array containing cluster numbers for B sample of objects in each simulation (first dimension represents simulation number, second - object number)
clusteringBB	2-dimensional array containing cluster numbers for B sample of objects in each simulation according to 4 step of replication analysis procedure (first dimension represents simulation number, second - object number)
cRand	value of mean corrected Rand index for S simulations

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#### See Also

[cluster.Sim](#), [hclust](#), [kmeans](#), [dist](#), [dist.BC](#), [dist.SM](#), [dist.GDM](#),  
[data.Normalization](#)



**Examples**

```
library(clusterSim)
data(data_ratio)
w <- replication.Mod(data_ratio, u=5, S=10)
print(w)
```

```
library(clusterSim)
data(data_binary)
replication.Mod(data_binary,"b", u=2, "medoids", NULL,"b1", "pam", fixedAsample=c(1,3,6,7))
```

---

shapes.blocks3d	<i>Generation of data set containing two clusters with untypical shapes (cube divided into two parts by main diagonal plane)</i>
-----------------	--

---

**Description**

Generation of data set containing two clusters with untypical shapes (cube starting at point (0,0,0) divided into two parts by main diagonal plane)

**Usage**

```
shapes.blocks3d(numObjects=180,shapesUnitSize=0.5, shape2coordinateX=1.2,
shape2coordinateY=1.2,shape2coordinateZ=1.2, outputCsv="", outputCsv2="",
outputColNames=TRUE, outputRowNames=TRUE)
```

**Arguments**

numObjects	number of objects in each cluster - positive integer value or vector with length=2
shapesUnitSize	length of one unit for shape (maximal height, width and depth of shape is 2*shapesUnitSize)
shape2coordinateX	maximal value for second shape in first (X) dimension
shape2coordinateY	maximal value for second shape in second (Y) dimension
shape2coordinateZ	maximal value for second shape in third (Z) dimension
outputCsv	optional, name of csv file with generated data (first column contains id, second - number of cluster and others - data)
outputCsv2	optional, name of csv (a comma as decimal point and a semicolon as field separator) file with generated data (first column contains id, second - number of cluster and others - data)
outputColNames	outputColNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains first row with column names
outputRowNames	outputRowNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains a vector of row names

**Value**

clusters            cluster number for each object  
 data                generated data - matrix with objects in rows and variables in columns

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**See Also**

[shapes.worms](#), [shapes.circles2](#), [shapes.circles3](#), [shapes.bulls.ey](#), [shapes.two.moon](#)

**Examples**

```
library(clusterSim)
library(rgl)
sb3d<-shapes.blocks3d(300,1,3,3,3)
plot3d(sb3d$data,col=rainbow(2)[sb3d$clusters])
```

---

shapes.circles2	<i>Generation of data set containing two clusters with untypical ring shapes (circles)</i>
-----------------	--

---

**Description**

Generation of data set containing two clusters with untypical ring shapes. For each point first random radius  $r$  from given interval is generated then random angle  $\alpha$  and finally the coordinates of point are calculated as  $(r \cdot \cos(\alpha), r \cdot \sin(\alpha))$ . For bull's eye data set second shape is filled circle ( $r$  starts from 0)

**Usage**

```
shapes.circles2(numObjects=180, shape1rFrom=0.75, shape1rTo=0.9, shape2rFrom=0.35,
  shape2rTo=0.5, outputCsv="", outputCsv2="", outputColNames=TRUE, outputRowNames=TRUE)
shapes.bulls.ey(numObjects=180, shape1rFrom=0.75, shape1rTo=0.95, shape2rTo=0.45,
  outputCsv="", outputCsv2="", outputColNames=TRUE, outputRowNames=TRUE)
```

**Arguments**

numObjects        number of objects in each cluster - positive integer value or vector with length=2,  
 shape1rFrom      minimal value of radius for first ring  
 shape1rTo        maximal value of radius for first ring  
 shape2rFrom      minimal value of radius for second ring  
 shape2rTo        maximal value of radius for second ring

outputCsv	optional, name of csv file with generated data (first column contains id, second - number of cluster and others - data)
outputCsv2	optional, name of csv (a comma as decimal point and a semicolon as field separator) file with generated data (first column contains id, second - number of cluster and others - data)
outputColNames	outputColNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains first row with column names
outputRowNames	outputRowNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains a vector of row names

**Value**

clusters	cluster number for each object
data	generated data - matrix with objects in rows and variables in columns

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**See Also**

[shapes.worms](#), [shapes.circles3](#), [shapes.bulls.eye](#), [shapes.two.moon](#), [shapes.blocks3d](#)

**Examples**

```
#Example1
library(clusterSim)
sc2<-shapes.circles2(180)
plot(sc2$data,col=rainbow(2)[sc2$clusters])

#Example2
library(clusterSim)
sbe<-shapes.bulls.eye(numObjects=c(120,60))
plot(sbe$data,col=rainbow(2)[sbe$clusters])
```

---

shapes.circles3	<i>Generation of data set containing three clusters with untypical ring shapes (circles)</i>
-----------------	--

---

**Description**

Generation of data set containing three clusters with untypical ring shapes. For each point first random radius  $r$  from given interval is generated then random angle  $\alpha$  and finally the coordinates of point are calculated as  $(r*\cos(\alpha),r*\sin(\alpha))$

**Usage**

```
shapes.circles3(numObjects=180, shape1rFrom=0.15, shape1rTo=0.3,
  shape2rFrom=0.55, shape2rTo=0.7, shape3rFrom=1.15, shape3rTo=1.3,
  outputCsv="", outputCsv2="", outputColNames=TRUE, outputRowNames=TRUE)
```

**Arguments**

numObjects	number of objects in each cluster - positive integer value or vector with length=3,
shape1rFrom	minimal value of radius for first ring
shape1rTo	maximal value of radius for first ring
shape2rFrom	minimal value of radius for second ring
shape2rTo	maximal value of radius for second ring
shape3rFrom	minimal value of radius for third ring
shape3rTo	maximal value of radius for third ring
outputCsv	optional, name of csv file with generated data (first column contains id, second - number of cluster and others - data)
outputCsv2	optional, name of csv (a comma as decimal point and a semicolon as field separator) file with generated data (first column contains id, second - number of cluster and others - data)
outputColNames	outputColNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains first row with column names
outputRowNames	outputRowNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains a vector of row names

**Value**

clusters	cluster number for each object
data	generated data - matrix with objects in rows and variables in columns

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**See Also**

[shapes.worms](#), [shapes.circles2](#), [shapes.bulls.eye](#), [shapes.two.moon](#), [shapes.blocks3d](#)

**Examples**

```
#Example1
library(clusterSim)
sc3a<-shapes.circles3(180)
plot(sc3a$data, col=rainbow(3)[sc3a$clusters])
```

```
#Example2
library(clusterSim)
sc3b<-shapes.circles3(numObjects=c(120,180,240))
plot(sc3b$data,col=rainbow(3)[sc3b$clusters])
```

---

shapes.two.moon	<i>Generation of data set containing two clusters with untypical shapes (similar to waxing and waning crescent moon)</i>
-----------------	--

---

### Description

Generation of data set containing two clusters with untypical shapes (similar to waxing and waning crescent moon). For each point first random radius  $r$  from given interval is generated then random angle  $\alpha$  and finally the coordinates of point are calculated as  $(a+\text{abs}(r*\cos(\alpha)),r*\sin(\alpha))$  for first shape and  $(-\text{abs}(r*\cos(\alpha)),r*\sin(\alpha)-b)$  for second shape

### Usage

```
shapes.two.moon(numObjects=180,shape1a=-0.4,shape2b=1,shape1rFrom=0.8,
shape1rTo=1.2,shape2rFrom=0.8, shape2rTo=1.2, outputCsv="", outputCsv2="",
outputColNames=TRUE, outputRowNames=TRUE)
```

### Arguments

numObjects	number of objects in each cluster - positive integer value or vector with length=2,
shape1a	parameter a for first shape
shape2b	parameter b for first shape
shape1rFrom	minimal value of radius for first shape
shape1rTo	maximal value of radius for first shape
shape2rFrom	minimal value of radius for second shape
shape2rTo	maximal value of radius for second shape
outputCsv	optional, name of csv file with generated data (first column contains id, second - number of cluster and others - data)
outputCsv2	optional, name of csv (a comma as decimal point and a semicolon as field separator) file with generated data (first column contains id, second - number of cluster and others - data)
outputColNames	outputColNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains first row with column names
outputRowNames	outputRowNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains a vector of row names

### Value

clusters	cluster number for each object
data	generated data - matrix with objects in rows and variables in columns

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**See Also**

[shapes.worms](#), [shapes.circles2](#), [shapes.circles3](#), [shapes.bulls.eyes](#), [shapes.blocks3d](#)

**Examples**

```
library(clusterSim)
stm<-shapes.two.moon(180)
plot(stm$data,col=rainbow(2)[stm$clusters])
```

---

shapes.worms	<i>Generation of data set containing two clusters with untypical parabolic shapes (worms)</i>
--------------	---

---

**Description**

Generation of data set containing two clusters with untypical parabolic shapes (first is given by  $y=x^2$ , second by  $y=-(x-a)^2+b$  with distortion from  $\langle -tol,+tol \rangle$ )

**Usage**

```
shapes.worms(numObjects=180, shape1x1=-2, shape1x2=2, shape2x1=-0.5,
  shape2x2=2.5, shape2a=1.5, shape2b=5.5, tol=0.1, outputCsv="", outputCsv2="",
  outputColNames=TRUE, outputRowNames=TRUE)
```

**Arguments**

numObjects	number of objects in each cluster - positive integer value or vector with length=2
shape1x1	starting value on abscissa axis for shape 1
shape1x2	end value on abscissa axis for shape 1
shape2x1	starting value on abscissa axis for shape 2
shape2x2	end value on abscissa axis for shape 2
shape2a	parameter a of shape 2
shape2b	parameter b of shape 2
tol	tolerance - each generated point is randomized by adding <code>runif(1,0,tol)</code>
outputCsv	optional, name of csv file with generated data (first column contains id, second - number of cluster and others - data)
outputCsv2	optional, name of csv (a comma as decimal point and a semicolon as field separator) file with generated data (first column contains id, second - number of cluster and others - data)

outputColNames outputColNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains first row with column names

outputRowNames outputRowNames=TRUE indicates that output file (given by outputCsv and outputCsv2 parameters) contains a vector of row names

**Value**

clusters cluster number for each object

data generated data - matrix with objects in rows and variables in columns

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**See Also**

[shapes.worms](#), [shapes.circles2](#), [shapes.circles3](#), [shapes.bulls.ey](#), [shapes.two.moon](#), [shapes.blocks3d](#)

**Examples**

```
library(clusterSim)
sw<-shapes.worms(180)
plot(sw$data,col=rainbow(2)[sw$clusters])
```

---

 speccl

*A spectral clustering algorithm*

---

**Description**

A spectral clustering algorithm. Cluster analysis is performed by embedding the data into the subspace of the eigenvectors of an affinity matrix

**Usage**

```
speccl(data,nc,distance="GDM1",sigma="automatic",sigma.interval="default",
mod.sample=0.75,R=10,iterations=3,na.action=na.omit,...)
```

**Arguments**

data matrix or dataset

nc the number of clusters

distance	distance function used to calculate affinity matrix: "sEuclidean" - squared Euclidean distance, "euclidean" - Euclidean distance, "manhattan" - city block distance, "maximum" - Chebyshev distance, "canberra" - Lance and Williams Canberra distance, "BC" - Bray-Curtis distance measure for ratio data, "GDM1" - GDM distance for metric data, "GDM2" - GDM distance for ordinal data, "SM" - Sokal-Michener distance measure for nominal variables
sigma	scale parameter used to calculate affinity matrix: sigma="automatic" - an algorithm for searching optimal value of sigma parameter; sigma=200 - value of sigma parameter given by researcher, e.g. 200
sigma.interval	sigma.interval="default" - from zero to square root of sum of all distances in lower triangle of distance matrix for "sEuclidean" and from zero to sum of all distances in lower triangle of distance matrix for other distances; sigma.interval=1000 - from zero to value given by researcher, e.g. 1000
mod.sample	proportion of data to use when estimating sigma (default: 0.75)
R	the number of intervals examined in each step of searching optimal value of sigma parameter algorithm (See <a href="#">../doc/speccl_details.pdf</a> )
iterations	the maximum number of iterations (rounds) allowed in algorithm of searching optimal value of sigma parameter
na.action	the action to perform on NA
...	arguments passed to kmeans procedure

### Details

See file [../doc/speccl\\_details.pdf](#) for further details

### Value

scdist	returns the lower triangle of the distance matrix
clusters	a vector of integers indicating the cluster to which each object is allocated
size	the number of objects in each cluster
withinss	the within-cluster sum of squared distances for each cluster
Ematrix	data matrix $n \times u$ ( $n$ - the number of objects, $u$ - the number of eigenvectors)
Ymatrix	normalized data matrix $n \times u$ ( $n$ - the number of objects, $u$ - the number of eigenvectors)
sigma	the value of scale parameter given by searching algorithm

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## See Also

[dist.GDM](#), [kmeans](#), [dist](#), [dist.binary](#), [dist.SM](#), [dist.BC](#)

## Examples

```
# Commented due to long execution time
# Example 1
#library(clusterSim)
#library(mlbench)
#data<-mlbench.spirals(100,1,0.03)
#plot(data)
#x<-data$x
#res1<-speccl(x,nc=2,distance="GDM1",sigma="automatic",
#sigma.interval="default",mod.sample=0.75,R=10,iterations=3)
#clas1<-res1$cluster
#print(data$classes)
#print(clas1)
#cRand<-classAgreement(table(as.numeric(as.vector(data$classes)),
#res1$clusters))$crand
#print(res1$sigma)
#print(cRand)

# Example 2
#library(clusterSim)
```

```
#grnd2<-cluster.Gen(50,model=4,dataType="m",numNoisyVar=1)
#data<-as.matrix(grnd2$data)
#colnames<-c("red","blue","green")
#grnd2$clusters[grnd2$clusters==0]<-length(colnames)
#plot(grnd2$data,col=colnames[grnd2$clusters])
#us<-nrow(data)*nrow(data)/2
#res2<-speccl(data,nc=3,distance="sEuclidean",sigma="automatic",
#sigma.interval=us,mod.sample=0.75,R=10,iterations=3)
#cRand<-comparing.Partitions(grnd2$clusters,res2$clusters,type="crand")
#print(res2$sigma)
#print(cRand)

# Example 3
#library(clusterSim)
#grnd3<-cluster.Gen(40,model=4,dataType="o",numCategories=7)
#data<-as.matrix(grnd3$data)
#plotCategorical(grnd3$data,pairsofVar=NULL,cl=grnd3$clusters,
#clColors=c("red","blue","green"))
#res3<-speccl(data,nc=3,distance="GDM2",sigma="automatic",
#sigma.interval="default",mod.sample=0.75,R=10,iterations=3)
#cRand<-comparing.Partitions(grnd3$clusters,res3$clusters,type="crand")
#print(res3$sigma)
#print(cRand)

# Example 4
library(clusterSim)
data(data_nominal)
res4<-speccl(data_nominal,nc=4,distance="SM",sigma="automatic",
sigma.interval="default",mod.sample=0.75,R=10,iterations=3)
print(res4)
```

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