

# Package ‘G1DBN’

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**Title** A package performing Dynamic Bayesian Network inference.

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**Depends** R (>= 2.11.1), MASS, igraph

**Description** G1DBN performs DBN inference using 1st order conditional  
dependencies.

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`arth800line`*Arabidopsis Thaliana temporal gene expression data*

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### Description

This data set describes the temporal log<sub>2</sub> transformed expression of 800 genes of *A. thaliana* during the diurnal cycle. The data are in line, that is 2 repeated measurements time series are displayed one after the other, separated by a 'NA' value. The 800 genes are a subset of the data presented in Smith et al. (2004) selected for periodicity according to the method implemented in the R package GeneCycle (<http://strimmerlab.org/software/genecycle/>).

### Usage

```
data(arth800line)
```

### Format

matrix with 800 columns (=genes) and 23 rows (rows 1 to 11 contain the first measurement time series, row 12 contain 'NA' values and rows 13 to 23 contain the second experiment time series).

### Author(s)

Lebre Sophie ([http://icube-bfo.unistra.fr/en/index.php/Sophie\\_Lebre](http://icube-bfo.unistra.fr/en/index.php/Sophie_Lebre)),  
Chiquet Julien (<http://stat.genopole.cnrs.fr/~jchiquet/>).

### Source

The microarray experiments were performed in the laboratory of S. Smith (Edinburgh). The data are available from the NASCArrays database (<http://affymetrix.arabidopsis.info/> under experiment reference number NASCARRAYS-60).

### References

Smith et al. 2004. Diurnal changes in the transcriptome encoding enzymes of starch metabolism provide evidence for both transcriptional and posttranscriptional regulation of starch metabolism in *Arabidopsis* leaves. *Plant Physiol.* 136: 2687-2699.

### Examples

```
## load G1DBN library
library(G1DBN)

## load data set
data(arth800line)
id<-c(60, 141, 260, 333, 365, 424, 441, 512, 521, 578, 789, 799)

## plot first ten time series
plot(1:23,arth800line[,60],type="l",ylim=c(2,12), xlab="Time",
```

```

ylab="Log2 transformed expression",lwd=2,
main="Log2 transformed expression of a subset of genes of A. Thaliana")

color=1
for (i in id){
  color=color+1
  lines(1:23,arth800line[,i,],col=color,lwd=2)
}

```

BuildEdges

*Edges listing and evaluation***Description**

Given a score matrix, this function builds the list of the edges of the associated network. The edges are ordered according to their scores. The score matrix has been computed from a network inference algorithm (e.g. DBNScoreStep1 or DBNScoreStep2, Shrinkage, Lasso, ...). An optional threshold can be specified, as well as a maximal number of edges.

**Usage**

```
BuildEdges(score, threshold=1, nb=NULL,
           targetNames=NULL, predNames=NULL, prec=3, dec=FALSE)
```

**Arguments**

score	matrix with $r$ rows (=target genes) and $d$ columns (=predictor genes) containing the scores resulting from an estimation procedure (e.g. DBNScoreStep1 or DBNScoreStep2, Shrinkage, Lasso, ...).
threshold	An optional real setting the maximal value for edge selection, default=1.
nb	An optional integer setting the maximal number of selected edges, default=NULL.
targetNames	An optional array ( $r$ ) giving a list of names for the target genes, default=NULL.
predNames	An optional array ( $d$ ) giving a list of names for the predictor genes, default=NULL.
prec	An optional integer setting the number of decimal places for score display, default=3.
dec	boolean, FALSE if the smallest score points out the most significant edge, default=FALSE.

**Value**

A matrix containing a list of edges ordered according to the score (First column: predictor, second column: target, third column: corresponding score). Predictors and targets are referred to through the names given by targetNames or predNames when specified.

**Author(s)**

Lebre Sophie ([http://icube-bfo.unistra.fr/en/index.php/Sophie\\_Lebre](http://icube-bfo.unistra.fr/en/index.php/Sophie_Lebre)),  
 Chiquet Julien (<http://stat.genopole.cnrs.fr/~jchiquet>).

**See Also**

DBNScoreStep1, DBNScoreStep2, BuildNetwork

**Examples**

```
library(G1DBN)
## =====
## SIMULATING THE NETWORK

## number of genes
p <- 10
## the network - adjacency Matrix
MyNet <- SimulNetworkAdjMatrix(p,0.05,c(-1.5,-0.5,0.5,1.5))
MyNet

## =====
## SIMULATING THE TIME SERIES EXPERIMENTS

## number of time points
n <- 20
## initializing the B vector
B <- runif(p,-1,1)
## initializing the variance of the noise
sigmaEps <- runif(p,0.1,0.5)
## initializing the process Xt
X0 <- B + rnorm(p,0,sigmaEps*10)
## the times series process
Xn <- SimulGeneExpressionAR1(MyNet$A,B,X0,sigmaEps,n)

## =====
## NETWORK INFERENCE WITH G1DBN

## STEP 1 - The first step score matrix
S1 <- DBNScoreStep1(Xn, method='ls')

## Building the edges of the network inferred after Step1
alpha1 <- 0.5
G1 <- BuildEdges(S1$S1ls,threshold=alpha1,dec=FALSE)
G1

## STEP 2- The second step score matrix
S2 <- DBNScoreStep2(S1$S1ls, Xn, method='ls', alpha1)

## Building the edges of the network inferred after Step2
alpha2 <- 0.05
G2 <- BuildEdges(S2,threshold=alpha2,dec=FALSE)
G2
```

```
## Building the edges of the simulation Graph
Gsimul <- BuildEdges(MyNet$AdjMatrix,threshold=0,dec=TRUE)
Gsimul
```

---

**BuildNetwork***Network object creation*

---

### Description

Given a list of scored edges and a REQUIRED vector of labels (e.g, 1:p), this function builds an object "Network". This is useful for exporting a network described by a list of edges to a network described by an adjacency matrix.

### Usage

```
BuildNetwork(Edges,Labels,nonedges.val=NA)
```

### Arguments

Edges	a $n \times 3$ matrix (each line contains a couple of vertices plus the associated score)
Labels	a vector of labels for the vertices
nonedges.val	optional. Value attributed to the not existing edges in the generated score matrix out\$Score, default=NA

### Value

a list that contains out\$Vertices\$Num the number of vertices, out\$Vertices\$Labels a vector of labels of the vertices, out\$Vertices\$Connected a vector of the connected vertices, out\$Edges\$Prop the proportion of edges, out\$Edges\$Num the number of edges, the graph of the network (out\$AdjMatrix an adjacency matrix and out\$Edges\$List a list of edges) and out\$Score a score matrix.

### Author(s)

Lebre Sophie ([http://icube-bfo.unistra.fr/en/index.php/Sophie\\_Lebre](http://icube-bfo.unistra.fr/en/index.php/Sophie_Lebre)),

Chiquet Julien (<http://stat.genopole.cnrs.fr/~jchiquet>).

### See Also

BuildEdges

**Examples**

```

library(G1DBN)

## =====
## SIMULATING THE NETWORK
## -----

## number of genes
p <- 10
## number of time points
n <- 20
## proportion of genes
geneProp <- 0.05
## the network - adjacency Matrix
MyNet <- SimulNetworkAdjMatrix(p,geneProp,c(-1.5,-0.5,0.5,1.5))

cat("\n=====\n")
cat("SIMULATION\n")

## =====
## SIMULATING THE TIME SERIES EXPERIMENTS
## -----
##
## Autoregressive model
##
cat("Time series experiments with")

## initializing the B vector
B <- runif(p,-1,1)
## initializing the variance of the noise
sigmaEps <- runif(p,0.1,0.5)
## initializing the process Xt
X0 <- B + rnorm(p,0,sigmaEps*10)
## the times series process
Xn <- SimulGeneExpressionAR1(MyNet$A,B,X0,sigmaEps,n)

## =====
## NETWORK INFERENCE WITH G1DBN
## -----
##
cat("\n=====\n")
cat("NETWORK INFERENCE\n")
cat("Using a Dynamic Bayesian Network model\n")

## STEP 1
## -----
cat("STEP 1...\n")
S1 <- DBNScoreStep1(Xn, method='ls')

## STEP 2
## -----
cat("STEP 2...\n")

```

```

alpha1=0.5
S2 <- DBNScoreStep2(S1$S1ls, data=Xn, method='ls', alpha1=alpha1)

## =====
## POST TREATMENTS

## building the inferred Graph
G1 <- BuildEdges(S1$S1ls,threshold=alpha1,dec=FALSE)

## encoding as the adjacency matrix graph
Step1InferredNet <- BuildNetwork(G1,1:p)
Step1InferredNet

#Step 2
alpha2=0.05
G2 <- BuildEdges(S2,threshold=alpha2,dec=FALSE)
Step2InferredNet <- BuildNetwork(G2,1:p)

## =====
## PLOTTING THE RESULTS...
## -----
## Not run:
cat("\n=====\\n")
cat("SUMMARY\\n")
cat("Plotting the results...\\n")
split.screen(c(1,3))

## The Original graph and data
## -----
# set the edges list of the simulated network
G0 <- BuildEdges(MyNet$AdjMatrix,threshold=0.9,dec=TRUE)

## Nodes coordinates are calculated according to the global structure of the network
all_parents=c(G0[,1],G1[,1], G2[,1])
all_targets=c(G0[,2],G1[,2], G2[,2])
posEdgesG0=1:dim(G0)[1]
posEdgesG1=(dim(G0)[1]+1):(dim(G0)[1]+dim(G1)[1])
posEdgesG2=(dim(G0)[1]+dim(G1)[1]+1):length(all_parents)

## Global network with all the edges
netAll =
graph.edgelist(cbind(as.character(all_parents),as.character(all_targets)))

## Nodes coordinates
nodeCoord=layout.fruchterman.reingold(netAll)

#after Step 1
screen(1)
# set the edges list
netG1 = graph.edgelist(cbind(as.character(G1[,1]),as.character(G1[,2])))

```

```

# set the object for plotting the network with global coordinates of all nodes
G1toPlot=delete.edges(netAll, E(netAll)[c(posEdgesG0,posEdgesG2)-1] )
# plot the network
plot(G1toPlot, layout=nodeCoord, vertex.label =
get.vertex.attribute(G1toPlot, name="name"), edge.arrow.size = 0.2,
main="G1DBN Inferred network:\n Step 1")

#after Step 2
screen(2)
# set the edges list
netG2 = graph.edgelist(cbind(as.character(G2[,1]),as.character(G2[,2])))
# set the object for plotting the network with global coordinates of all nodes
G2toPlot=delete.edges(netAll, E(netAll)[c(posEdgesG0,posEdgesG1)-1 ] )
# plot the network
plot(G2toPlot, layout=nodeCoord, vertex.label =
get.vertex.attribute(G2toPlot, name="name"),edge.arrow.size = 0.2,
main="G1DBN Inferred network:\n Step 2")

screen(3)
net0 = graph.edgelist(cbind(as.character(G0[,1]),as.character(G0[,2])))
# set the object for plotting the network with global coordinates of all nodes
G0toPlot=delete.edges(netAll, E(netAll)[c(posEdgesG1,posEdgesG2)-1] )
plot(G0toPlot, layout=nodeCoord, vertex.label =
get.vertex.attribute(G0toPlot, name="name"), edge.arrow.size = 0.2,
main="Simulated network:")

close.screen(all = TRUE)

## End(Not run)
cat("")
cat("\nDONE !\n")

```

---

DBNScoreStep1

*First order dependence graph G(1) inference*


---

## Description

Given a time series dataset for  $p$  genes, this function infers a 1st order dependence score matrix  $S1$  ( $p \times p$ ) which contains the score of each edge of a Dynamic Bayesian Network (DAG  $G(1)$ ) describing first order dependencies between successive variables. The smallest score points out the most significant edge for the 1st order dependence DAG  $G(1)$ . The sets of both predictor and target genes can be reduced to different subsets of the  $p$  genes. DBNScoreStep1 is the first step of the estimation procedure described in the references. See function DBNScoreStep2 to perform the second step selection and infer a score matrix describing full order dependencies.

## Usage

```
DBNScoreStep1(data,method='ls',predPosition=NULL,targetPosition=NULL)
```

**Arguments**

<code>data</code>	a matrix with $n$ rows (=time points) and $p$ columns (=genes) containing the gene expression time series.
<code>method</code>	currently M estimation with either LS, Tukey bisquare or Huber estimator: c('ls', 'tukey', 'huber'), default='ls'.
<code>predPosition</code>	To be specified to reduce the set of possible predictor genes to a subset of $d < p$ genes: an array included in $[1, p]$ defining the position of the $d$ predictor genes in the data matrix ( $n \times p$ ), default=NULL.
<code>targetPosition</code>	To be specified to reduce the set of possible target genes to a subset of $r < p$ genes: an array included in $[1, p]$ defining the position of the $r$ target genes in the data matrix ( $n \times p$ ), default=NULL.

**Value**

A list with out\$S1ls a matrix with  $\min(r, p)$  rows (=target genes) and  $\min(d, p)$  columns (=predictor genes) containing the scores S1 obtained with least square estimator, out\$S1huber a matrix containing scores S1 obtained with Huber estimator, out\$S1tukey a matrix containing scores S1 obtained with Tukey bisquare (or biweight) estimator.(out\$S1ls[i,j] is the score for the edge  $j \leftarrow i$  pointing out from predictor  $j$  toward target  $i$ .)

**Note**

For a large number of target genes, it is of interest to parallel run the procedure DBNScoreStep1 for each target gene by running  $p$  the following jobs for  $i = 1 \dots p$ ,

```
outi <- DBNScoreStep1(data, target=i).
```

**Author(s)**

Lebre Sophie ([http://icube-bfo.unistra.fr/en/index.php/Sophie\\_Lebre](http://icube-bfo.unistra.fr/en/index.php/Sophie_Lebre)),

Chiquet Julien (<http://stat.genopole.cnrs.fr/~jchiquet>).

**References**

Lebre, S. 2009. Inferring dynamic bayesian network with low order independencies, Statistical Applications in Genetics and Molecular Biology, 2009: Vol. 8: Iss. 1, Article 9.

**See Also**

DBNScoreStep2, BuildEdges, PRcurve.

**Examples**

```
## load G1DBN Library
library(G1DBN)

data(arth800line)
data<-as.matrix(arth800line)
id<-c(60, 141, 260, 333, 365, 424, 441, 512, 521, 578, 789, 799)
```

```

names<-c("carbohydrate/sugar transporter","ATGPX2","putative integral
membrane prot" ,
"AT3G05900", "At3g27350", "At1g16720","ATISA3/ISA3","AT4G32190",
"catalase", "plasma membrane intrinsic prot", "At4g16146", "DPE2")

## compute score S1
out<-DBNScoreStep1(data,method='ls', targetPosition=id,predPosition=id)
round(out$S1ls,2)

## Threshold for the selection of the edges after Step 1
alpha1=0.5
## Build the edges with id as label
edgesG1id<-BuildEdges(score=out$S1ls,threshold=alpha1,
targetNames=id,predNames=id,prec=6)
## Build the edges with names as label
edgesG1names<-BuildEdges(score=out$S1ls,threshold=alpha1,
targetNames=names,predNames=names,prec=6)

edgesG1id[1:15,]
edgesG1names[1:15,]

## compute score S2 from S1
S2<-DBNScoreStep2(out$S1ls,data,method='ls',alpha1=alpha1,
predPosition=id,targetPosition=id)
S2

## Threshold for the selection of the edges after Step 2
alpha2=0.05
## Build the edges with id as label
edgesG2id<-BuildEdges(score=S2,threshold=alpha2,
targetNames=id,predNames=id,prec=6)
## Build the edges with names as label
edgesG2names<-BuildEdges(score=S2,threshold=alpha2,
targetNames=names,predNames=names,prec=6)

edgesG2id
edgesG2names

## As the number of genes is reduced to 10 here, this results slightly differ
## from the results obtained in the paper (Lebre, 2009) cited in References.

## =====
## PLOTTING THE RESULTS...
## -----
## Not run:
## The Inferred Nets
## -----

## Nodes coordinates are calculated according to the global structure of the graph
all_parents=c(edgesG1id[,1], edgesG2id[,1])
all_targets=c(edgesG1id[,2], edgesG2id[,2])

```

```

posEdgesG1=1:dim(edgesG1id)[1]
posEdgesG2=(dim(edgesG1id)[1]+1):length(all_targets)

## Global network with all the edges
netAll = graph.edgelist(cbind(as.character(all_parents),as.character(all_targets )))

## Nodes coordinates
nodeCoord=layout.fruchterman.reingold(netAll)

split.screen(c(1,2))

# after Step 1
screen(1)
# set the edges list
netG1 = graph.edgelist(cbind(as.character(edgesG1id[,1]),as.character(edgesG1id[,2])))
# set the object for plotting the network with global coordinates of all nodes
G1toPlot=delete.edges(netAll, E(netAll)[posEdgesG2] )
# plot the network
plot(G1toPlot, layout=nodeCoord, vertex.label =
get.vertex.attribute(G1toPlot , name="name"), edge.arrow.size = 0.2,
main="G1DBN Inferred network:\n Step 1")

# after Step 2
screen(2)
# set the edges list

netG2 = graph.edgelist(cbind(as.character(edgesG2id[,1]),as.character(edgesG2id[,2])))
# set the object for plotting the network with global coordinates of all nodes
G2toPlot=delete.edges(netAll, E(netAll)[posEdgesG1] )
# plot the network
plot(G2toPlot, layout=nodeCoord, vertex.label =
get.vertex.attribute(G2toPlot , name="name"),edge.arrow.size = 0.2,
main="G1DBN Inferred network:\n Step 2")

close.screen(all = TRUE)

## End(Not run)

```

---

DBNScoreStep2

*Full order dependence DAG G score matrix inference from a 1st order dependence score matrix S1*


---

## Description

Given a time series dataset for  $p$  genes, a 1st order dependence score matrix  $S1$  (obtained with function `DBNScoreStep1`) and a threshold  $\alpha_1$  for edge selection in matrix  $S1$ , this function infers the score of each edge of a Dynamic Bayesian Network (DAG  $G$ ) describing full order dependencies between successive variables. This is the second step of the inference procedure described

in the references. 1st step DBNScoreStep1 allows to reduce the number of potential edges, DBNScoreStep2 performs the last step selection. The smallest score points out the most significant edge.

### Usage

```
DBNScoreStep2(S1,data,method='ls',alpha1,predPosition=NULL,
              targetPosition=NULL)
```

### Arguments

S1	a matrix with $r$ rows (=target genes) and $d$ columns (=predictor genes) containing score S1 (maximal p-value) obtained with function DBNScoreStep1.
data	a matrix with $n$ rows (=time points) and $p$ columns (=genes) containing the gene expression time series.
method	one of 'ls' (default), 'huber', 'tukey'. This specifies the regression method.
alpha1	Threshold for edge selection in the 1st order dependence score matrix S1. Edges having a score greater than alpha1 are pruned and quoted 'NA' is the resulting score matrix S2.
predPosition	To be specified if the number $d$ of predictor genes in score matrix S1 is lower than the number $p$ of genes in the data: an array included in $[1, p]$ defining the position of the $d$ predictor genes in the data matrix ( $n \times p$ ), default=NULL.
targetPosition	To be specified if the number $r$ of target genes in score matrix S1 is lower than the number $p$ of genes in the data: an array included in $[1, p]$ defining the position of the $r$ target genes in the data matrix ( $n \times p$ ), default=NULL.

### Value

A matrix ( $r$  rows,  $d$  columns) containing the scores S2 obtained after the second step inference with the chosen M estimator. The score of the edges pruned after the first step inference is 'NA'.

### Author(s)

Lebre Sophie ([http://icube-bfo.unistra.fr/en/index.php/Sophie\\_Lebre](http://icube-bfo.unistra.fr/en/index.php/Sophie_Lebre)),

Chiquet Julien (<http://stat.genopole.cnrs.fr/~jchiquet>).

### References

Lebre, S. 2009. Inferring dynamic bayesian network with low order independencies, Statistical Applications in Genetics and Molecular Biology, 2009: Vol. 8: Iss. 1, Article 9.

### See Also

DBNScoreStep1, BuildEdges.

**Examples**

```

## load G1DBN Library
library(G1DBN)

data(arth800line)
data<-as.matrix(arth800line)
id<-c(60, 141, 260, 333, 365, 424, 441, 512, 521, 578, 789, 799)
names<-c("carbohydrate/sugar transporter","ATGPX2","putative integral
membrane prot" ,
"AT3G05900", "At3g27350", "At1g16720","ATISA3/ISA3","AT4G32190",
"catalase", "plasma membrane intrinsic prot", "At4g16146", "DPE2")

## compute score S1
out<-DBNScoreStep1(data,method='ls', targetPosition=id,predPosition=id)
round(out$S1s,2)

## Threshold for the selection of the edges after Step 1
alpha1=0.5
## Build the edges with id as label
edgesG1id<-BuildEdges(score=out$S1s,threshold=alpha1,
targetNames=id,predNames=id,prec=6)
## Build the edges with names as label
edgesG1names<-BuildEdges(score=out$S1s,threshold=alpha1,
targetNames=names,predNames=names,prec=6)
edgesG1id[1:15,]
edgesG1names[1:15,]

## compute score S2 from S1
S2<-DBNScoreStep2(out$S1s,data,method='ls',alpha1=alpha1,
predPosition=id,targetPosition=id)
S2

## Threshold for the selection of the edges after Step 2
alpha2=0.05
## Build the edges with id as label
edgesG2id<-BuildEdges(score=S2,threshold=alpha2,
targetNames=id,predNames=id,prec=6)
## Build the edges with names as label
edgesG2names<-BuildEdges(score=S2,threshold=alpha2,
targetNames=names,predNames=names,prec=6)
edgesG2id
edgesG2names

## As the number of genes is reduced to 10 here, this results slightly differ
## from the results obtained in the paper (Lebre, 2009) cited in References.

## =====
## PLOTTING THE RESULTS...

```

```

## -----
## Not run:
## The Inferred Nets
## -----

## Nodes coordinates are calculated according to the global structure of the graph
all_parents=c(edgesG1id[,1], edgesG2id[,1])
all_targets=c(edgesG1id[,2], edgesG2id[,2])
posEdgesG1=1:dim(edgesG1id)[1]
posEdgesG2=(dim(edgesG1id)[1]+1):length(all_targets)

## Global network with all the edges
netAll = graph.edgelist(cbind(as.character(all_parents),as.character(all_targets )))

## Nodes coordinates
nodeCoord=layout.fruchterman.reingold(netAll)

split.screen(c(1,2))

# after Step 1
screen(1)
# set the edges list
netG1 = graph.edgelist(cbind(as.character(edgesG1id[,1]),as.character(edgesG1id[,2])))
# set the object for plotting the network with global coordinates of all nodes
G1toPlot=delete.edges(netAll, E(netAll)[posEdgesG2] )
# plot the network
plot(G1toPlot, layout=nodeCoord, vertex.label =
get.vertex.attribute(G1toPlot , name="name"),edge.arrow.size = 0.2,
main="G1DBN Inferred network:\n Step 1")

# after Step 2
screen(2)
# set the edges list

netG2 = graph.edgelist(cbind(as.character(edgesG2id[,1]),as.character(edgesG2id[,2])))
# set the object for plotting the network with global coordinates of all nodes
G2toPlot=delete.edges(netAll, E(netAll)[posEdgesG1] )
# plot the network
plot(G2toPlot, layout=nodeCoord, vertex.label =
get.vertex.attribute(G2toPlot , name="name"),edge.arrow.size = 0.2,
main="G1DBN Inferred network:\n Step 2")

close.screen(all = TRUE)

## End(Not run)

```

## Description

Given a score matrix and a validation matrix, this function allows to compute the corresponding Precision-Recall (PR) curve by returning a list with the respective  $x$  coordinates (recall) and  $y$  coordinates (precision) of the PR curve. The recall is equal to the sensitivity, that is the number of true positive out of the number of true edges to be detected. The precision is the Positive Predictive Value, that is the number of true positive edges out of the number of selected edges. The score matrix has been computed from a network inference algorithm (e.g. DBNScoreStep1 or DBNScoreStep2, Shrinkage, Lasso, ...).

## Usage

```
PRcurve(score, validMat, dec=FALSE)
```

## Arguments

score	matrix with $r$ rows (=target genes) and $d$ columns (=predictor genes) containing the scores resulting from an estimation procedure (e.g. DBNScoreStep1 or DBNScoreStep2, Shrinkage, Lasso, ...).
validMat	An optional matrix specifying the validated edges (1 if an edge is validated, 0 otherwise).
dec	boolean, FALSE if the smallest score points out the most significant edge, default=FALSE.

## Value

A list with `out$recall` and `out$precision` containing respectively the recall values ( $x$  coordinates of the PR curve) and the precision values ( $y$  coordinates).

## Author(s)

Lebre Sophie ([http://icube-bfo.unistra.fr/en/index.php/Sophie\\_Lebre](http://icube-bfo.unistra.fr/en/index.php/Sophie_Lebre)),  
Chiquet Julien (<http://stat.genopole.cnrs.fr/~jchiquet>).

## See Also

DBNScoreStep1, DBNScoreStep2, ROCcurve.

## Examples

```
library(G1DBN)
## generate the validation matrix
## number of genes
p <- 20
## the network - adjacency Matrix
MyNet <- SimulNetworkAdjMatrix(p,0.05,c(-1,0.5,0.5,1))

## generate the time series
## initializing the B vector
B <- runif(p,-1,1)
```

```

## initializing the variance of the noise
sigmaEps <- runif(p,0.05,0.5)
## initializing the process Xt
X0 <- B + rnorm(p,0,sigmaEps*10)
## number of time points
n <- 20

## the AR(1) times series process
Xn <- SimulGeneExpressionAR1(MyNet$A,B,X0,sigmaEps,n)

## compute score S1
out<-DBNScoreStep1(Xn)
pr1<-PRcurve(score=out$S1ls,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

## compute score S2 from S1
## depending on the generated data, the threshold alpha1 has to be chosen differently.
alpha1=0.8
S2<-DBNScoreStep2(S1=out$S1ls,data=Xn,alpha1=alpha1)
pr2_0.8<-PRcurve(score=S2,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

alpha1=0.6
S2<-DBNScoreStep2(S1=out$S1ls,data=Xn,alpha1=alpha1)
pr2_0.6<-PRcurve(score=S2,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

alpha1=0.4
S2<-DBNScoreStep2(S1=out$S1ls,data=Xn,alpha1=alpha1)
pr2_0.4<-PRcurve(score=S2,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

alpha1=0.2
S2<-DBNScoreStep2(S1=out$S1ls,data=Xn,alpha1=alpha1)
pr2_0.2<-PRcurve(score=S2,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

plot(pr1$recall,pr1$precision,type="l",main="PR curves after both Step1 and Step2",
      ylab="PPV", xlab="Sensitivity",lwd=2, xlim=c(0,1),ylim=c(0,1),lty=2)
lines(pr2_0.8$recall,pr2_0.8$precision, col=3,lwd=2)
lines(pr2_0.6$recall,pr2_0.6$precision, col=4,lwd=2)
lines(pr2_0.4$recall,pr2_0.4$precision, col=5,lwd=2)
lines(pr2_0.2$recall,pr2_0.2$precision, col=6,lwd=2)
lines(0:1,c(0,0),lty=3)
lines(0:1,c(1,1),lty=3)
lines(c(0,0),0:1,lty=3)
lines(c(1,1),0:1,lty=3)

leg=c("Step 1", "Step 2 (alpha1=0.8)", "Step 2 (alpha1=0.6)",
      "Step 2 (alpha1=0.4)", "Step 2 (alpha1=0.2)")
legend(0,0.265, leg, lty=c(2,1,1,1,1), col=c(1,3,4,5,6),lwd=array(2,5))

```

## Description

Given a score matrix and a validation matrix, this function allows to compute the corresponding ROC curve by returning a list with the respective  $x$  and  $y$  coordinates of the ROC curve. The score matrix has been computed from a network inference algorithm (e.g. DBNScoreStep1 or DBNScoreStep2, Shrinkage, Lasso, ...).

## Usage

```
ROCcurve(score, validMat, dec=FALSE)
```

## Arguments

score	matrix with $r$ rows (=target genes) and $d$ columns (=predictor genes) containing the scores resulting from an estimation procedure (e.g. DBNScoreStep1 or DBNScoreStep2, Shrinkage, Lasso, ...).
validMat	An optional matrix specifying the validated edges (1 if an edge is validated, 0 otherwise).
dec	boolean, FALSE if the smallest score points out the most significant edge, default=FALSE.

## Value

A list with out $x$  and out $y$  contain respectively the  $x$  and the  $y$  coordinates of the ROC curve.

## Author(s)

Lebre Sophie ([http://icube-bfo.unistra.fr/en/index.php/Sophie\\_Lebre](http://icube-bfo.unistra.fr/en/index.php/Sophie_Lebre)),  
Chiquet Julien (<http://stat.genopole.cnrs.fr/~jchiquet>).

## See Also

DBNScoreStep1, DBNScoreStep2, PRcurve.

## Examples

```
## generate the validation matrix
## number of genes
p <- 20
## the network - adjacency Matrix
MyNet <- SimulNetworkAdjMatrix(p,0.05,c(-1,0.5,0.5,1))

## generate the time series
## initializing the B vector
B <- runif(p,-1,1)
## initializing the variance of the noise
sigmaEps <- runif(p,0.05,0.5)
## initializing the process Xt
X0 <- B + rnorm(p,0,sigmaEps*10)
## number of time points
n <- 20
```

```

## the AR(1) times series process
Xn <- SimulGeneExpressionAR1(MyNet$A,B,X0,sigmaEps,n)

## compute score S1
out<-DBNScoreStep1(Xn)
roc1<-ROCcurve(score=out$S1ls,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

## compute score S2 from S1
## depending on the generated data, the threshold alpha1 has to be chosen differently.
alpha1=0.8
S2<-DBNScoreStep2(S1=out$S1ls,data=Xn,alpha1=alpha1)
roc2_0.8<-ROCcurve(score=S2,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

alpha1=0.6
S2<-DBNScoreStep2(S1=out$S1ls,data=Xn,alpha1=alpha1)
roc2_0.6<-ROCcurve(score=S2,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

alpha1=0.4
S2<-DBNScoreStep2(S1=out$S1ls,data=Xn,alpha1=alpha1)
roc2_0.4<-ROCcurve(score=S2,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

alpha1=0.2
S2<-DBNScoreStep2(S1=out$S1ls,data=Xn,alpha1=alpha1)
roc2_0.2<-ROCcurve(score=S2,validMat=abs(MyNet$AdjMatrix)>0,dec=FALSE)

TP=sum(abs(MyNet$AdjMatrix)>0)
FN=p^2-TP

plot(roc1$x/FN,roc1$y/TP,type="l", main="ROC curve after both Step1 and Step2",
     ylab="True Positive Rate", xlab="False Negative Rate",lwd=2,lty=2)
lines(roc2_0.8$x/FN, roc2_0.8$y/TP, col=3,lwd=2)
lines(roc2_0.6$x/FN, roc2_0.6$y/TP, col=4,lwd=2)
lines(roc2_0.4$x/FN, roc2_0.4$y/TP, col=5,lwd=2)
lines(roc2_0.2$x/FN, roc2_0.2$y/TP, col=6,lwd=2)
lines(0:1,c(0,0),lty=3)
lines(0:1,c(1,1),lty=3)
lines(c(0,0),0:1,lty=3)
lines(c(1,1),0:1,lty=3)
leg=c("Step 1", "Step 2 (alpha1=0.8)", "Step 2 (alpha1=0.6)",
      "Step 2 (alpha1=0.4)", "Step 2 (alpha1=0.2)")
legend(0.568,0.265, leg, lty=c(2,1,1,1,1), col=c(1,3,4,5,6),lwd=array(2,5))

```

**Description**

This function generates multivariate time series according to the following first order Auto-Regressive process,

$$X(t) = AX(t - 1) + B + \varepsilon(t),$$

where  $\varepsilon(t)$  follows a zero-centered multivariate gaussian distribution whose variance matrix  $S$  is diagonal.

**Usage**

```
SimulGeneExpressionAR1(A,B,X0,SigmaEps,n)
```

**Arguments**

A	a matrix ( $p \times p$ )
B	a column vector ( $p \times 1$ )
X0	a column vector ( $p \times 1$ ) containing the values of the process at time 0
SigmaEps	a column vector ( $p \times 1$ ) containing the values of the diagonal of covariance matrix S
n	the desired length of the time serie.

**Value**

A matrix, with  $n$  rows (=length) and  $p$  columns (=dimension), containing the generated time series,

**Author(s)**

Lebre Sophie ([http://icube-bfo.unistra.fr/en/index.php/Sophie\\_Lebre](http://icube-bfo.unistra.fr/en/index.php/Sophie_Lebre)),  
Chiquet Julien (<http://stat.genopole.cnrs.fr/~jchiquet>).

**See Also**

SimulNetworkAdjMatrix

**Examples**

```
library(G1DBN)
## number of genes
p <- 20
## the network - adjacency Matrix
MyNet <- SimulNetworkAdjMatrix(p,0.05,c(-1,0,0,1))

## initializing the B vector
B <- runif(p,0,0.5)
## initializing the variance of the noise
sigmaEps <- runif(p,0.1,0.8)
## initializing the process Xt
X0 <- B + rnorm(p,0,sigmaEps*10)
## number of time points
```

```

n <- 30

## the AR(1) time series process
Xn <- SimulGeneExpressionAR1(MyNet$A,B,X0,sigmaEps,n)

plot(1:n, Xn[,1],type="l", xlab="Time t", ylab="X(t)",
main="Simulated AR(1) time series", ylim=c(min(Xn),max(Xn)))

for (i in 2:p){
  lines(1:n,Xn[,i],col=i)
}

```

---

SimulNetworkAdjMatrix *Network object generation*

---

### Description

This function builds a object "Network" by simulating a matrix of valued adjacencies from a number of vertices, a proportion of edges and the range of the uniform distribution that is used to build the adjacency matrix. An optional vector of labels may be given.

### Usage

```
SimulNetworkAdjMatrix(Num,EdgesProp,Range,Labels=1:Num)
```

### Arguments

Num	number of genes
EdgesProp	edges proportion in the network
Range	vector with 4 elements specifying range values for the adjacency matrix generation (minimum negative value, maximum negative value, minimum positive value, maximum positive value)
Labels	an optional vector of labels for the edges

### Value

a list that contains out\$Vertices\$Num the number of vertices, out\$Vertices\$Labels a vector of labels of the vertices, out\$Vertices\$Regulated a vector of the regulated vertices, out\$Edges\$Prop the proportion of edges, out\$Edges\$Num the number of edges, out\$AdjMatrix an adjacency matrix (binary) and out\$A a valued adjacency matrix.

### Author(s)

Lebre Sophie ([http://icube-bfo.unistra.fr/en/index.php/Sophie\\_Lebre](http://icube-bfo.unistra.fr/en/index.php/Sophie_Lebre)),  
 Chiquet Julien (<http://stat.genopole.cnrs.fr/~jchiquet>).

**See Also**

SimulGeneExpressionAR1, BuildEdges

**Examples**

```
library(G1DBN)
## number of genes
p <- 10
## the network - adjacency Matrix
MyNet <- SimulNetworkAdjMatrix(p,0.05,c(-1,0,0,1))
MyNet

## initializing the B vector
B <- runif(p,0,0.5)
## initializing the variance of the noise
sigmaEps <- runif(p,0.1,0.8)
## initializing the process Xt
X0 <- B + rnorm(p,0,sigmaEps*10)
## number of time points
n <- 20

## the AR(1) times series process
Xn <- SimulGeneExpressionAR1(MyNet$AdjMatrix,B,X0,sigmaEps,n)
```

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