

# Package ‘AMOUNTAIN’

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**Type** Package

**Title** Active modules for multilayer weighted gene co-expression networks: a continuous optimization approach

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## **Description**

A pure data-driven gene network, weighted gene co-expression network (WGCN) could be constructed only from expression profile. Different layers in such networks may represent different time points, multiple conditions or various species. AMOUNTAIN aims to search active modules in multi-layer WGCN using a continuous optimization approach.

**License** GPL (>= 2)

**Depends** R (>= 3.3.0)

**Imports** stats

**RoxygenNote** 5.0.1

**SystemRequirements** gsl

**biocViews** GeneExpression, Microarray, DifferentialExpression, Network

**Suggests** BiocStyle, qgraph, knitr, rmarkdown

**VignetteBuilder** knitr

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## Contents

CGPFixSS . . . . .	2
CGPFixSSMultiLayer . . . . .	3
CGPFixSSTwoplayer . . . . .	4
EuclideanProjectionENNORM . . . . .	6
moduleIdentificationGPFixSS . . . . .	7
moduleIdentificationGPFixSSMultilayer . . . . .	8
moduleIdentificationGPFixSSTwoplayer . . . . .	9
multilayernetworkSimulation . . . . .	10
networkSimulation . . . . .	11
twolayernetworkSimulation . . . . .	12

<b>Index</b>	<b>14</b>
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CGPFixSS	<i>Module Identification</i>
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### Description

Call C version of moduleIdentificationGPFixSS

### Usage

```
CGPFixSS(W, z, x0, a = 0.5, lambda = 1, maxiter = 50)
```

### Arguments

W	edge score matrix of the network, n x n matrix
z	node score vector of the network, n-length vector
x0	initial solution, n-length vector
a	parameter in elastic net the same as in <a href="#">EuclideanProjectionENNORM</a>
lambda	parameter in objective, coefficient of node score part
maxiter	maximal iteration of whole procedure

### Value

a list containing function objective vector and the solution

### Author(s)

Dong Li, <dx1466@cs.bham.ac.uk>

### References

AMOUNTAIN

**See Also**

[moduleIdentificationGPFixSS](#)

**Examples**

```
n = 100
k = 20
theta = 0.5
pp <- networkSimulation(n,k,theta)
moduleid <- pp[[3]]
## use default parameters here
x <- CGPFixSS(pp[[1]],pp[[2]],rep(1/n,n))
predictedid<-which(x[[2]]!=0)
recall <- length(intersect(predictedid,moduleid))/length(moduleid)
precise <- length(intersect(predictedid,moduleid))/length(predictedid)
Fscore <- (2*precise*recall/(precise+recall))
```

---

CGPFixSSMultiLayer      *Module Identification for multi-layer network*

---

**Description**

Call C version of moduleIdentificationGPFixSSMultilayer

**Usage**

```
CGPFixSSMultiLayer(W, listzs, x0, a = 0.5, lambda = 1, maxiter = 50)
```

**Arguments**

W	edge score matrix of the network, n x n matrix
listzs	a list of node score vectors, each layer has a n-length vector
x0	initial solution, n-length vector
a	parameter in elastic net the same as in <a href="#">EuclideanProjectionENNORM</a>
lambda	parameter in objective, coefficient of node score of other layers
maxiter	maximal iteration of whole procedure

**Value**

a list containing solution for network 1 and network 2

**Author(s)**

Dong Li, <dx1466@cs.bham.ac.uk>

**References**

AMOUNTAIN

**See Also**

[moduleIdentificationGPFixSSMultilayer](#)

**Examples**

```
n = 100
k = 20
L = 5
theta = 0.5
cpl <- multilayernetworkSimulation(n,k,theta,L)
listz <- list()
for (i in 1:L){
  listz[[i]] <- cpl[[i+2]]
}
moduleid <- cpl[[2]]
## use default parameters here
x <- CGPFixSSMultiLayer(cpl[[1]],listz,rep(1/n,n))
predictedid <- which(x[[2]]!=0)
recall <- length(intersect(predictedid,moduleid))/length(moduleid)
precise <- length(intersect(predictedid,moduleid))/length(predictedid)
Fscore <- (2*precise*recall)/(precise+recall)
```

---

CGPFixSSTwolayer

*Module Identification for two-layer network*

---

**Description**

Call C version of moduleIdentificationGPFixSSTwolayer

**Usage**

```
CGPFixSSTwolayer(W1, z1, x0, W2, z2, y0, interlayerA, lambda1 = 1,
  lambda2 = 1, lambda3 = 1, maxiter = 100, a1 = 0.5, a2 = 0.5)
```

**Arguments**

W1	edge score matrix of the network 1, $n_1 \times n_1$ matrix
z1	node score vector of the network 1, $n_1$ -length vector
x0	initial solution of network 1, $n_1$ -length vector
W2	edge score matrix of the network 2, $n_2 \times n_2$ matrix
z2	node score vector of the network 2, $n_2$ -length vector
y0	initial solution of network 2, $n_2$ -length vector
interlayerA	inter-layer links weight, $n_1 \times n_2$ matrix
lambda1	parameter in objective, coefficient of node score of network 1
lambda2	parameter in objective, coefficient of node score of network 2

lambda3	parameter in objective, coefficient of inter-layer links part
maxiter	maximal iteration of whole procedure
a1	parameter in elastic net the same as in <a href="#">EuclideanProjectionENNORM</a>
a2	parameter in elastic net the same as in <a href="#">EuclideanProjectionENNORM</a>

**Value**

a list containing solution for network 1 and network 2 and objective

**Author(s)**

Dong Li, <dxl466@cs.bham.ac.uk>

**References**

AMOUNTAIN

**See Also**

[moduleIdentificationGPFixSSTwoplayer](#)

**Examples**

```

n1=100
k1=20
theta1 = 0.5
n2=80
k2=10
theta2 = 0.5
ppresult <- twolayernetworkSimulation(n1,k1,theta1,n2,k2,theta2)
A <- ppresult[[3]]
pp <- ppresult[[1]]
moduleid <- pp[[3]]
netid <- 1:n1
restp<- netid[-moduleid]
pp2 <- ppresult[[2]]
moduleid2 <- pp2[[3]]
## use default parameters here
modres=CGPFixSSTwoplayer(pp[[1]],pp[[2]],rep(1/n1,n1),
pp2[[1]],pp2[[2]],rep(1/n2,n2),A)
predictedid<-which(modres[[1]]!=0)
recall = length(intersect(predictedid,moduleid))/length(moduleid)
precise = length(intersect(predictedid,moduleid))/length(predictedid)
F1 = 2*precise*recall/(precise+recall)
predictedid2<-which(modres[[2]]!=0)
recall2 = length(intersect(predictedid2,moduleid2))/length(moduleid2)
precise2 = length(intersect(predictedid2,moduleid2))/length(predictedid2)
F2 = 2*precise2*recall2/(precise2+recall2)

```

---

EuclideanProjectionENNORM

*Euclidean projection on elastic net*

---

### Description

Piecewise root finding algorithm for Euclidean projection on elastic net

### Usage

```
EuclideanProjectionENNORM(y, t, alpha = 0.5)
```

### Arguments

y	constant vector
t	radius of elastic net ball
alpha	parameter in elastic net: $\alpha x_1 + (1-\alpha)x_2^2=t$

### Value

a list containing network adjacency matrix, node score and module membership

### Author(s)

Dong Li, <dx1466@cs.bham.ac.uk>

### References

Gong, Pinghua, Kun Gai, and Changshui Zhang. "Efficient euclidean projections via piecewise root finding and its application in gradient projection." *Neurocomputing* 74.17 (2011): 2754-2766.

### Examples

```
y=rnorm(100)
x=EuclideanProjectionENNORM(y,1,0.5)
sparistyx = sum(x==0)/100
```

---

moduleIdentificationGPFixSS  
*Module Identification*

---

**Description**

Algorithm for Module Identification on single network

**Usage**

```
moduleIdentificationGPFixSS(W, z, x0, a = 0.5, lambda = 1, maxiter = 1000)
```

**Arguments**

W	edge score matrix of the network, n x n matrix
z	node score vector of the network, n-length vector
x0	initial solution, n-length vector
a	parameter in elastic net the same as in <a href="#">EuclideanProjectionENNORM</a>
lambda	parameter in objective, coefficient of node score part
maxiter	maximal iteration of whole procedure

**Value**

a list containing function objective vector and the solution

**Author(s)**

Dong Li, <dxl466@cs.bham.ac.uk>

**References**

AMOUNTAIN

**See Also**

[EuclideanProjectionENNORM](#)

**Examples**

```
n = 100
k = 20
theta = 0.5
pp <- networkSimulation(n,k,theta)
moduleid <- pp[[3]]
## use default parameters here
x <- moduleIdentificationGPFixSS(pp[[1]],pp[[2]],rep(1/n,n))
predictedid<-which(x[[2]]!=0)
```

```
recall <- length(intersect(predictedid,moduleid))/length(moduleid)
precise <- length(intersect(predictedid,moduleid))/length(predictedid)
Fscore <- (2*precise*recall/(precise+recall))
```

---

moduleIdentificationGPFixSSMultilayer

*Module Identification for multi-layer network*

---

### Description

Algorithm for Module Identification on multi-layer network sharing the same set of genes

### Usage

```
moduleIdentificationGPFixSSMultilayer(W, listz, x0, a = 0.5, lambda = 1,
  maxiter = 1000)
```

### Arguments

W	edge score matrix of the network, n x n matrix
listz	a list of node score vectors, each layer has a n-length vector
x0	initial solution, n-length vector
a	parameter in elastic net the same as in <a href="#">EuclideanProjectionENNORM</a>
lambda	parameter in objective, coefficient of node score of other layers
maxiter	maximal iteration of whole procedure

### Value

a list containing objective values and solution

### Author(s)

Dong Li, <dxl466@cs.bham.ac.uk>

### References

AMOUNTAIN

### See Also

[moduleIdentificationGPFixSSMultilayer](#)



**Examples**

```

n = 100
k = 20
L = 5
theta = 0.5
cpl <- multilayernetworkSimulation(n,k,theta,L)
listz <- list()
for (i in 1:L){
  listz[[i]] <- cpl[[i+2]]
}
moduleid <- cpl[[2]]
## use default parameters here
x <- moduleIdentificationGPFixSSMultilayer(cpl[[1]],listz,rep(1/n,n))
predictedid <- which(x[[2]]!=0)
recall <- length(intersect(predictedid,moduleid))/length(moduleid)
precise <- length(intersect(predictedid,moduleid))/length(predictedid)
Fscore <- (2*precise*recall/(precise+recall))

```

---

```

moduleIdentificationGPFixSSTwolayer

```

*Module Identification for two-layer network*

---

**Description**

Algorithm for Module Identification on two-layer network

**Usage**

```

moduleIdentificationGPFixSSTwolayer(W1, z1, x0, W2, z2, y0, A, lambda1 = 1,
  lambda2 = 1, lambda3 = 1, maxiter = 1000, a1 = 0.5, a2 = 0.5)

```

**Arguments**

W1	edge score matrix of the network 1, $n_1 \times n_1$ matrix
z1	node score vector of the network 1, $n_1$ -length vector
x0	initial solution of network 1, $n_1$ -length vector
W2	edge score matrix of the network 2, $n_2 \times n_2$ matrix
z2	node score vector of the network 2, $n_2$ -length vector
y0	initial solution of network 2, $n_2$ -length vector
A	inter-layer links weight, $n_1 \times n_2$ matrix
lambda1	parameter in objective, coefficient of node score of network 1
lambda2	parameter in objective, coefficient of node score of network 2
lambda3	parameter in objective, coefficient of inter-layer links part
maxiter	maximal iteration of whole procedure
a1	parameter in elastic net the same as in <a href="#">EuclideanProjectionENNORM</a>
a2	parameter in elastic net the same as in <a href="#">EuclideanProjectionENNORM</a>

**Value**

a list containing solution for network 1 and network 2 and objective

**Author(s)**

Dong Li, <dx1466@cs.bham.ac.uk>

**References**

AMOUNTAIN

**See Also**

[EuclideanProjectionENNORM](#)

**Examples**

```
n1=100
k1=20
theta1 = 0.5
n2=80
k2=10
theta2 = 0.5
ppresult <- twolayernetworkSimulation(n1,k1,theta1,n2,k2,theta2)
A <- ppresult[[3]]
pp <- ppresult[[1]]
moduleid <- pp[[3]]
netid <- 1:n1
restp<- netid[-moduleid]
pp2 <- ppresult[[2]]
moduleid2 <- pp2[[3]]
## use default parameters here
modres=moduleIdentificationGPFixSSTwoplayer(pp[[1]],pp[[2]],rep(1/n1,n1),
pp2[[1]],pp2[[2]],rep(1/n2,n2),A)
predictedid<-which(modres[[1]]!=0)
recall = length(intersect(predictedid,moduleid))/length(moduleid)
precise = length(intersect(predictedid,moduleid))/length(predictedid)
F1 = 2*precise*recall/(precise+recall)
predictedid2<-which(modres[[2]]!=0)
recall2 = length(intersect(predictedid2,moduleid2))/length(moduleid2)
precise2 = length(intersect(predictedid2,moduleid2))/length(predictedid2)
F2 = 2*precise2*recall2/(precise2+recall2)
```

**Description**

Simulate a multi-layer weighted network with each layer sharing the same set of nodes but different nodes scores

**Usage**

```
multilayernetworkSimulation(n, k, theta, L)
```

**Arguments**

n	number of nodes in each layer of the network
k	number of nodes in the conserved module
theta	module node score follow the uniform distribution in range [theta,1]
L	number of layers

**Value**

a list containing all the layers, each as result object of [networkSimulation](#)

**Author(s)**

Dong Li, <dxl466@cs.bham.ac.uk>

**See Also**

[networkSimulation](#)

**Examples**

```
n = 100
k = 20
theta = 0.5
L = 5
cpl <- multilayernetworkSimulation(n,k,theta,L)
## No proper way to visualize it yet
```

---

networkSimulation      *Illustration of weighted network simulation*

---

**Description**

Simulate a single weighted network

**Usage**

```
networkSimulation(n, k, theta)
```

**Arguments**

n                    number of nodes in the network  
k                    number of nodes in the module,  $n < k$   
theta                module node score follow the uniform distribution in range [theta,1]

**Value**

a list containing network adjacency matrix, node score and module membership

**Author(s)**

Dong Li, <dxl466@cs.bham.ac.uk>

**Examples**

```
pp <- networkSimulation(100,20,0.5)
moduleid <- pp[[3]]
netid <- 1:100
restp<- netid[-moduleid]
groupdesign=list(moduleid,restp)
names(groupdesign)=c('module','background')
## Not run: library(qgraph)
pg<-qgraph(pp[[1]],groups=groupdesign,legend=TRUE)
## End(Not run)
```

---

twolayernetworkSimulation

*Illustration of two-layer weighted network simulation*

---

**Description**

Simulate a two-layer weighted network

**Usage**

```
twolayernetworkSimulation(n1, k1, theta1, n2, k2, theta2)
```

**Arguments**

n1                    number of nodes in the network1  
k1                    number of nodes in the module1,  $n1 < k1$   
theta1                module1 node score follow the uniform distribution in range [theta1,1]  
n2                    number of nodes in the network2  
k2                    number of nodes in the module2,  $n2 < k2$   
theta2                module2 node score follow the uniform distribution in range [theta2,1]

**Value**

a list containing network1, network2 and a inter-layer links matrix

**Author(s)**

Dong Li, <dx1466@cs.bham.ac.uk>

**See Also**

[networkSimulation](#)

**Examples**

```
n1=100
k1=20
theta1 = 0.5
n2=80
k2=10
theta2 = 0.5
ppresult <- twolayernetworkSimulation(n1,k1,theta1,n2,k2,theta2)
A <- ppresult[[3]]
pp <- ppresult[[1]]
moduleid <- pp[[3]]
netid <- 1:n1
restp<- netid[-moduleid]
pp2 <- ppresult[[2]]
moduleid2 <- pp2[[3]]
netid2 <- 1:n2
restp2<- netid2[-moduleid2]
## labelling the groups
groupdesign=list(moduleid,restp,(moduleid2+n1),(restp2+n1))
names(groupdesign)=c('module1','background1','module2','background2')
twolayernet<-matrix(0,nrow=(n1+n2),ncol=(n1+n2))
twolayernet[1:n1,1:n1]<-pp[[1]]
twolayernet[(n1+1):(n1+n2),(n1+1):(n1+n2)]<-pp2[[1]]
twolayernet[1:n1,(n1+1):(n1+n2)] = A
twolayernet[(n1+1):(n1+n2),1:n1] = t(A)
## Not run: library(qgraph)
g<-qgraph(twolayernet,groups=groupdesign,legend=TRUE)
## End(Not run)
```

# Index

- \* **Euclidean**
    - EuclideanProjectionENNORM, [6](#)
  - \* **identification,**
    - CGPFixSSMultiLayer, [3](#)
    - CGPFixSSTwoplayer, [4](#)
    - moduleIdentificationGPFixSSMultilayer, [8](#)
    - moduleIdentificationGPFixSSTwoplayer, [9](#)
  - \* **identification**
    - CGPFixSS, [2](#)
    - moduleIdentificationGPFixSS, [7](#)
  - \* **module**
    - CGPFixSS, [2](#)
    - CGPFixSSMultiLayer, [3](#)
    - CGPFixSSTwoplayer, [4](#)
    - moduleIdentificationGPFixSS, [7](#)
    - moduleIdentificationGPFixSSMultilayer, [8](#)
    - moduleIdentificationGPFixSSTwoplayer, [9](#)
  - \* **multi-layer**
    - CGPFixSSMultiLayer, [3](#)
    - moduleIdentificationGPFixSSMultilayer, [8](#)
  - \* **projection**
    - EuclideanProjectionENNORM, [6](#)
  - \* **simulation**
    - multilayernetworkSimulation, [10](#)
    - networkSimulation, [11](#)
    - twolayernetworkSimulation, [12](#)
  - \* **two-layer**
    - CGPFixSSTwoplayer, [4](#)
    - moduleIdentificationGPFixSSTwoplayer, [9](#)
- CGPFixSS, [2](#)  
CGPFixSSMultiLayer, [3](#)  
CGPFixSSTwoplayer, [4](#)
- EuclideanProjectionENNORM, [2](#), [3](#), [5](#), [6](#), [7–10](#)  
moduleIdentificationGPFixSS, [3](#), [7](#)  
moduleIdentificationGPFixSSMultilayer, [4](#), [8](#), [8](#)  
moduleIdentificationGPFixSSTwoplayer, [5](#), [9](#)  
multilayernetworkSimulation, [10](#)  
networkSimulation, [11](#), [11](#), [13](#)  
twolayernetworkSimulation, [12](#)