Package ‘BiRewire’

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Title High-performing routines for the randomization of a bipartite graph (or a binary event matrix), undirected and directed signed graph preserving degree distribution (or marginal totals)

Maintainer Andrea Gobbi <gobbi.andrea@mail.com>

Description Fast functions for bipartite network rewiring through N consecutive switching steps (See References) and for the computation of the minimal number of switching steps to be performed in order to maximise the dissimilarity with respect to the original network. Includes functions for the analysis of the introduced randomness across the switching steps and several other routines to analyse the resulting networks and their natural projections. Extension to undirected networks and directed signed networks is also provided. Starting from version 1.9.7 a more precise bound (especially for small network) has been implemented. Starting from version 2.2.0 the analysis routine is more complete and a visual monitoring of the underlying Markov Chain has been implemented.

License GPL-3

Depends igraph, slam, tsne, Matrix
Suggests RUnit, BiocGenerics

Author Andrea Gobbi [aut], Francesco Iorio [aut], Giuseppe Jurman [cbt], Davide Albanese [cbt], Julio Saez-Rodriguez [cbt].

URL http://www.ebi.ac.uk/~iorio/BiRewire
biocViews Network

NeedsCompilation yes

R topics documented:

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R package for computationally-efficient rewiring of bipartite graphs (or randomisation of 0-1 tables with prescribed marginal totals), undirected and directed signed graphs (dsg). The package provides useful functions for the analysis and the randomisation of large biological datasets that can be encoded as 0-1 tables, hence modeled as bipartite graphs by considering a 0-1 table as an incidence matrix, and for data that can be encoded as directed signed graphs such as pathways and signaling networks. Large collections of such randomised tables can be used to approximate null models, preserving event-rates both across rows and columns, for statistical significance tests of combinatorial properties of the original dataset. The package provides an interface to a sampler routine useful for generating correctly such collections. Moreover a visual monitoring for the Markov Chain underlying the swithicng algorithm has been implemented.

Details

Summary:

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Author(s)

Andrea Gobbi [aut], Davide Albanese [cbt], Francesco Iorio [cbt], Giuseppe Jurman [cbt].

Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>
References


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birewire.analysis.bipartite

Analysis of Jaccard similarity trends across switching steps.

Description

This function performs a sequence of max.iter switching steps on the input bipartite graph g and compute the Jaccard similarity between g (the initial network) and its rewired version each step switching steps. This procedure is performed n.networks times and a simple explorative plot, with mean and CI, is visualized if display is set to true.

Usage

birewire.analysis.bipartite(incidence, step=10, max.iter="n",accuracy=0.00005, verbose=TRUE,MAXITER_MUL=10,exact=FALSE,n.networks=50,display=TRUE)

Arguments

incidence Incidence matrix of the initial bipartite graph g (can be extracted from an igraph bipartite graph using the get.incidence function);

step 10 (default): the interval (in terms of switching steps) at which the Jaccard index between g and the its current rewired version is computed);

max.iter "n" (default) the number of switching steps to be performed (or if exact=TRUE the number of successful switching steps). If equal to "n" then this number is considered equal to the analytically derived lower bound presented in Gobbi et al. (see References): \( N = \frac{e}{2(1-d)} \ln \left( \frac{(e-de)}{\delta} \right) \) if exact is FALSE, \( N = \frac{e(1-d)}{2} \ln \left( \frac{(e-de)}{\delta} \right) \) otherwise , where e is the number of edges of g and d its edge density . This bound is much lower than the empirical one proposed in Milo et al. 2003 (see References);

accuracy 0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;
birewire.analysis.bipartite

verbose TRUE (default). When TRUE a progression bar is printed during computation;

MAXITER_MUL 10 (default). If exact==TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;

exact FALSE (default). If TRUE the program performs max.iter switching steps, otherwise the program will count also the not-performed swithcing steps;

n.networks 50 (default), the number of independent rewiring process starting from the same initial graph from which the mean value and the CI is computed.

display TRUE (default). If TRUE two explorative plots are displayed summarizing the trend of the Jaccard index in terms of mean and confidence interval.

Details

This function performs max.iter switching steps (see references). In particular, at each step two edges are randomly selected from the current version of g. Let these two edges be (a, b) and (c, d) (where a and c belong to the first class of nodes whereas b and d belong to the second one), with a ≠ c and b ≠ d.

If the (a, d) and (c, b) edges are not already present in the current current version of g then (a, d) and(c, b) replace (a, b) and (c, d).

At each step number of switching steps the function computes the Jaccard index between the original graph g and its current version.

This procedure is perfomed n.networks times and if display is set to TRUE, two explorative plots showing the mean value of the Jaccard Index over the SS and its CI are displayed.

Value

A list containing a data.frame data collecting all the Jacard index computed (each row is a run of the SA), and the analytically derived lower bound N of switching steps to be performed by the switching algorithm in order to provide the revired version of g with the maximal level of achievable randomness (in terms of dissimilarity from the initial g).

Author(s)

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>
Special thanks to:
Davide Albanese

References


Examples

```r
library(BiRewire)
g <- graph.bipartite(rep(0:1,length=10), c(1:10))

## get the incidence matrix of g
m <- as.matrix(get.incidence(graph=g))

## set parameters
step = 1
max = 100*length(E(g))

## perform two different analysis using two different maximal number of switching steps
scores <- birewire.analysis.bipartite(m, step, max, n.networks=10)
scores2 <- birewire.analysis.bipartite(m, step, "n", n.networks=10)
```

Description

This function performs a sequence of `max.iter.pos` (and `max.iter.pos`) switching steps on the positive (and negative) part of the input dsg `g` and computes the Jaccard similarity between `g` (the initial network) and its rewired version each `step` switching steps. This procedure is performed `n.networks` times and a simple explorative plot, with mean and CI, is visualized if `display` is set to `TRUE`. The plot shows the trend of the Jaccard Index relative to the positive (and negative) part of `g`.

Usage

```r
birewire.analysis.dsg(dsg, step=10, max.iter.pos='n', max.iter.neg='n', accuracy=0.00005, verbose=TRUE, MAXITER_MUL=10, exact=FALSE, n.networks=50, display=TRUE)
```

Arguments

dsg The initial dsg object (see `birewire.induced.bipartite`). Note that the dsg must contain a list of two incidence matrices and not igraph bipartite graphs.

step 10 (default): the interval (in terms of switching steps) at which the Jaccard index between `g` and the its current rewired version is computed;

max.iter.pos "n" (default) the number of switching steps to be performed (or if `exact=TRUE` the number of successful switching steps) for the positive part of `g`. See `birewire.rewire.bipartite` for more details;

max.iter.neg "n" (default) the same of `max.iter.p` but relative to the negative part;

accuracy 0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;

verbose TRUE (default). When TRUE a progression bar is printed during computation;

MAXITER_MUL 10 (default). If `exact=TRUE` in order to prevent a possible infinite loop the program stops anyway after `MAXITER_MUL*max.iter` iterations;
<table>
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<tr>
<td><code>exact</code></td>
<td>FALSE (default). If TRUE the program performs <code>max.iter</code> switching steps, otherwise the program will count also the not-performed switching steps;</td>
</tr>
<tr>
<td><code>n.networks</code></td>
<td>50 (default), the number of independent rewiring process starting from the same initial graph from which the mean value and the CI is computed.</td>
</tr>
<tr>
<td><code>display</code></td>
<td>TRUE (default). If TRUE two explorative plots are displayed summarizing the trend of the Jaccard index in terms of mean and confidence interval.</td>
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**Details**

This procedure acts in the same way of `birewire.analysis.bipartite` but in the case of dsg. The similarity is measured using `birewire.similarity.dsg`.

**Value**

A list containing two lists: `data` that is a list collecting all the Jaccard index computed (each row is a run of the SA) for the positive and negative part, and a list with the analytically derived lower bounds \( N \) for the positive and negative part of \( g \).

**Author(s)**

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>

**References**


**Examples**

```r
library(BiRewire)
data(test_dsg)
dsg <- birewire.induced.bipartite(test_dsg,sparse=FALSE)
a=birewire.analysis.dsg(dsg,verbose=FALSE,step=1,exact=TRUE,max.iter.pos=200,max.iter.neg=50)
```
birewire.analysis.undirected

Analysis of Jaccard similarity trends across switching steps.

Description
This function performs a sequence of max.iter switching steps on the input undirected graph \( g \) and compute the Jaccard similarity between \( g \) (the initial network) and its rewired version each step switching steps. This procedure is performed \( n.networks \) times and a simple explorative plot, with mean and CI, is visualized if display is set to TRUE.

Usage
birewire.analysis.undirected(adjacency, step=10, max.iter="n",accuracy=0.00005, verbose=TRUE,MAXITER_MUL=10,exact=FALSE,n.networks=50,display=TRUE)

Arguments
adjacency Incidence matrix of the initial bipartite graph \( g \) (can be extracted from an igraph undirected graph using the get.adjacency function);
step 10 (default): the interval (in terms of switching steps) at which the Jaccard index between \( g \) and its current rewired version is computed;
max.iter "n" (default): the number of switching steps to be performed (or if exact==TRUE the number of successful switching steps). If equal to "n" then this number is considered equal to the analytically derived lower bound presented in Gobbi et al. (see References): \( N = e/(2d^3 - dd^2 + 2d + 2) \ln((e - de)/\delta) \) if exact is FALSE, \( N = e(1 - d)/2 \ln((e - de)/\delta) \) otherwise, where \( e \) is the number of edges of \( g \) and \( d \) its edge density. This bound is much lower than the empirical one proposed in Milo et al. 2003 (see References);
accuracy 0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;
verbose TRUE (default). When TRUE a progression bar is printed during computation;
MAXITER_MUL 10 (default). If exact==TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;
exact FALSE (default). If TRUE the program performs max.iter switching steps, otherwise the program will count also the not-performed switching steps;
n.networks 50 (default), the number of independent rewiring process starting from the same initial graph from which the mean value and the CI is computed.
display TRUE (default). If TRUE two explorative plots are displayed summarizing the trend of the Jaccard index in terms of mean and confidence interval.

Details
This function performs max.iter switching steps (see references). In particular, at each step two edges are randomly selected from the current version of \( g \). Let these two edges be \((a, b)\) and \((c, d)\), with \( a \neq c, b \neq d, a \neq d, b \neq c \).
If the \((a, d)\) and \((c, b)\) (or \((a, d)\) and \((b, d)\)) edges are not already present in the current version of \( g \) then \((a, d)\) and \((c, b)\) replace \((a, b)\) and \((c, d)\) (or \((a, b)\) and \((c, d)\) replace \((a, c)\) and \((b, d)\)). If both
of the configurations are allowed, then one of them is randomly selected.

At each step number of switching steps the function computes the **Jaccard index** between the original graph \( g \) and its current version. This procedure is performed \( n\text{-networks} \) times and if display is set to TRUE, two explorative plots showing the mean value of the Jaccard Index over the SS and its CI are displayed.

**Value**

A list containing a data.frame data collecting all the Jaccard index computed (each row is a run of the SA), and the analytically derived lower bound \( N \) of switching steps to be performed by the switching algorithm in order to provide the revised version of \( g \) with the maximal level of achievable randomness (in terms of dissimilarity from the initial \( g \)).

**Author(s)**

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>
Special thanks to:
Davide Albanese

**References**


**Examples**

library(BiRewire)
g <- erdos.renyi.game(1000,0.1)
## get the incidence matrix of g
m<-as.matrix(get.adjacency(graph=g,sparse=FALSE))
## set parameters
step=100
max=100*length(E(g))
## perform two different analysis using two different numbers of switching steps
scores<-birewire.analysis.undirected(m,step,max,n.networks=10,verbose=FALSE)
scores2<-birewire.analysis.undirected(m,step,"n",n.networks=10,verbose=FALSE)
birewire.bipartite.from.incidence

Converts an incidence matrix into a bipartite graph.

Description
This function creates an igraph bipartite graph from an incidence matrix.

Usage
birewire.bipartite.from.incidence(matrix,directed=FALSE)

Arguments
matrix  incidence matrix: an (n-by-m) binary matrix where rows correspond to vertices in the frist class while columns correspond to vertices in the second one;
directed Logical, if TRUE a directed graph is created.

Details
The function calls graph.incidence of package igraph. See igraph documentation for more details.

Value
Bipartite igraph graph.

Author(s)
Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>

References

Examples
library(igraph)
library(BiRewire)
g <- graph.bipartite( rep(0:1,length=10), c(1:10))
  ##gets the incidence matrix of g
m<-as.matrix(get.incidence(graph=g))
  ##rewire the current graph
m2=birewire.rewire.bipartite(m,100)
  #create the rewired bipartite graph
g2<-birewire.bipartite.from.incidence(m2,TRUE)
### birewire.build.dsg

**Transform a dsg object in a SIF file.**

**Description**

The routine transforms the initial dsg (two bipartite graphs) into SIF dsg format.

**Usage**

```r
g = birewire.induced.bipartite(g)
```

**Arguments**

- `g` : The dsg to be converted;
- `delimitators` : list(negative='-',positive='+')(default):a list with 'positive' and 'negative' names identifying the character encoding the relation;

**Details**

This function converts the dsg object into a SIF format that can be saved using `birewire.write.dsg`, an internal function, using the given delimitators for encoding the relations. It is the inverse function of `birewire.induced.bipartite`.

**Value**

A dsg in SIF format.

**Examples**

```r
data(test_dsg)
g = birewire.induced.bipartite(test_dsg)
tmp = birewire.rewire.dsg(g, verbose=FALSE)
dsg2 = birewire.build.dsg(tmp)
```

### birewire.induced.bipartite

**Transform a SIF data frame into a dsg object (a list of positive and negative incidence matrix).**

**Description**

The routine transforms the initial dsg graph in SIF format into a dsg object made of two bipartite graphs: one for positive edges and the other for negative edges.

**Usage**

```r
g = birewire.induced.bipartite(g, delimitators=list(negative='-',positive='+'), sparse=FALSE)
```
birewire.load.dsg

Arguments

g A dataframe in SIF format describing a dsg (for example the output of \texttt{birewire.load.dsg};
delimators list(negative='-',positive='+') (default): a list with 'positive' and 'negative' names identifying the character encoding the relation;
sparse FALSE (default): if TRUE the two bipartite graphs are saved as \texttt{igraph} bipartite graphs;

Details

This function extracts the positive and negative part of \( g \) and creates a dsg object that can be used for example in the rewiring algorithm. It is the inverse function of \texttt{birewire.build.dsg}.

Value

A list of two incidence matrix or bipartite \texttt{igraph} objects.

References


Examples

\begin{verbatim}
data(test_dsg)
dsg=birewire.induced.bipartite(test_dsg)
\end{verbatim}

---

\texttt{birewire.load.dsg} \textit{Read a SIF file from a given path}

Description

The routine reads a SIF file and returns a R table.

Usage

\texttt{birewire.load.dsg(path)}

Arguments

path Path to the SIF file.

Value

A R table that can be transformed into a dsg using \texttt{birewire.induced.bipartite}
birewire.rewire.bipartite

Efficient rewiring of bipartite graphs

Description

Optimal implementation of the switching algorithm. It returns the rewired version of the initial bipartite graph or its incidence matrix.

Usage

birewire.rewire.bipartite(incidence, max.iter="n", accuracy=0.00005, verbose=TRUE, MAXITER_MUL=10, exact=FALSE)

Arguments

incidence

Incidence matrix of the initial bipartite graph g (can be extracted from an igraph bipartite graph using the get.incidence function; or the entire bipartite igraph graph

max.iter

"n" (default) the number of switching steps to be performed (or if exact=TRUE the number of successful switching steps). If equal to "n" then this number is considered equal to the analytically derived lower bound presented in Gobbi et al. (see References): \[ N = \frac{e}{2(1 - d)} \ln \left( \frac{(e - de)}{\delta} \right) \] if exact is FALSE, \[ N = \frac{e(1 - d)}{2 \ln \left( \frac{(e - de)}{\delta} \right)} \] otherwise, where \( e \) is the number of edges of \( g \) and \( d \) its edge density. This bound is much lower than the empirical one proposed in Milo et al. 2003 (see References);

accuracy

0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;

verbose

TRUE (default). When TRUE a progression bar is printed during computation.

MAXITER_MUL

10 (default). If exact=TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;

exact

FALSE (default). If TRUE the program performs max.iter swithcing steps, otherwise the program will count also the not-performed swithcing steps;

Details

Main function of the package. It performs at most max.iter switching steps producing a rewired version of an initial bipartite graph.

Value

Incidence matrix of the rewired graph or the igraph corresponding object depending on the input type.

Author(s)

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>
References


Examples

```r
library(igraph)
library(BiRewire)
g <- graph.bipartite( rep(0:1,length=10), c(1:10))
##gets the incidence matrix of g
m<-as.matrix(get.incidence(graph=g))
##rewiring
m2=birewire.rewire.bipartite(m,100*length(E(g)))
##creates the corresponding bipartite graph
g2<-birewire.bipartite.from.incidence(m2,directed=TRUE)
```

Description

This function performs the same analysis of `birewire.analysis.bipartite` but additionally it provides in output a rewired version of the two networks resulting from the natural projections of the initial graph, together with the corresponding Jaccard index trends.

Usage

```r
birewire.rewire.bipartite.and.projections(graph,step=10,max.iter="n", accuracy=0.00005,verbose=TRUE,MAXITER_MUL=10)
```

Arguments

graph A bipartite graph g:

max.iter "n" (default) the number of successful switching steps to be performed. If equal to "n" then this number is considered equal to the analytically derived lower bound \( N = e(1 - d)/2 \ln ((e - de)/\delta) \) presented in Gobbi et al. (see References);
step 10 (default): the interval (in terms of switching steps) at which the Jaccard index between \( g \) and its current rewired version is computed;

accuracy 0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;

verbose TRUE (default) boolean value. If TRUE print a processing bar during the rewiring algorithm.

MAXITER_MUL 10 (default). Since \( N \) indicates the number of successful switching steps, in order to prevent a possible infinite loop the program stops anyway after MAX-ITER_MUL*max.iter iterations;

Details

See \texttt{birewire.analysis.bipartite} for details.

Value

A list containing the three sequences of Jaccard index values (similarity_scores, similarity_scores.proj1, similarity_scores.proj2) for the three resulting graphs respectively (rewired, rewired.proj1, rewired.proj2). The first one is the rewired version of the initial graph \( g \), while the second and the third one are rewired versions of its natural projections.

Author(s)

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>

References


Examples

library(igraph)
library(BiRewire)

\( g \leftarrow \text{simplify(graph.bipartite( rep(0:1,length=100), c(c(1:100),seq(1,100,3),seq(1,100,7),100,seq(1,100,13), seq(1,100,17),seq(1,100,19),seq(1,100,23),100)))) \)
\# gets the incidence matrix of \( g \)
\( m \leftarrow \text{as.matrix(get.incidence(graph=g))} \)
\# rewrites \( g \) and its projections

\( \text{result=birewire.rewire.bipartite.and.projections(g,step=10,max.iter="n",accuracy=0.00005)} \)
birewire.rewire.dsg

Efficient rewiring of directed signed graphs

Description

Optimal implementation of the switching algorithm. It returns the rewired version of the initial directed signed graph (dsg).

Usage

birewire.rewire.dsg(dsg, exact=FALSE, verbose=1, max.iter.pos='n', max.iter.neg='n', accuracy=0.00005, MAXITER_MUL=10, path=NULL, delimiters=list(positive='+', negative=' -'))

Arguments

dsg A dsg object: is a list of two incidence matrices (see References), "positive" and "negative", encoding the positive edges and negative edges. This list can be obtained reading a SIF file using birewire.load.dsg function and converting the resulting dataframe using birewire.induced.bipartite;

exact FALSE (default). If TRUE the program performs max.iter successful switching steps, otherwise the program will count also the not-performed switching steps;

verbose TRUE (default). When TRUE a progression bar is printed during computation;

max.iter.pos "n" (default) the number of switching steps to be performed on the positive part of dsg (or if exact==TRUE the number of successful switching steps). If equal to "n" then this number is considered equal to the analytically derived lower bound presented in Gobbi et al. (see References): \[ N = \frac{e}{2(1-d)} \ln \left( \frac{e - de}{\delta} \right) \] if exact is FALSE, \[ N = \frac{e(1-d)}{2} \ln \left( \frac{e - de}{\delta} \right) \] otherwise, where \( e \) is the number of edges of \( g \) and \( d \) its edge density . This bound is much lower than the empirical one proposed in Milo et al. 2003 (see References);

max.iter.neg "n" (default) the number of switching steps to be performed on the negative part of dsg (or if exact==TRUE the number of successful switching steps). If equal to "n" then this number is considered equal to the analytically derived lower bound presented in Gobbi et al. (see References): \[ N = \frac{e}{2(1-d)} \ln \left( \frac{e - de}{\delta} \right) \] if exact is FALSE, \[ N = \frac{e(1-d)}{2} \ln \left( \frac{e - de}{\delta} \right) \] otherwise, where \( e \) is the number of edges of \( g \) and \( d \) its edge density . This bound is much lower than the empirical one proposed in Milo et al. 2003 (see References);

accuracy 0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;

MAXITER_MUL 10 (default). If exact==TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;

path NULL (default). If not NULL, the dsg is saved in path in SIF format;

delimiters list(positive='+', negative=' -') (default). If save.file is true, the dsg is saved using delimiters as characters encoding the relations. See birewire.build.dsg for more details.

Details

This function runs birewire.rewire.bipartite on the positive and negative part of dsg. See references for more details.
Value
Rewired dsg.

Author(s)
Andrea Gobbi: <gobbi.andrea@mail.com>

References


Examples

```r
library(BiRewire)
data(test_dsg)
dsg=birewire.induced.bipartite(test_dsg)
tmp= birewire.rewire.dsg(dsg,verbose=FALSE)
```

---

**birewire.rewire.undirected**

Efficient rewiring of undirected graphs

Description
Optimal implementation of the switching algorithm. It returns the rewired version of the initial undirected graph or its adjacency matrix.

Usage

```r
birewire.rewire.undirected(adjacency, max.iter="n",accuracy=0.00005, verbose=TRUE,MAXITER_MUL=10,exact=FALSE)
```

Arguments

- **adjacency**: An **igraph** undirected graph `g` or its adjacency matrix (can be extracted from `g` using `get.adjacency`);
max.iter  "n" (default) the number of switching steps to be performed (or if exact=TRUE the number of successful switching steps). If equal to "n" then this number is considered equal to the analytically derived lower bound presented in Gobbi et al. (see References): $N = \frac{e}{(2d^3 - 6d^2 + 2d + 2) \ln (e - de)}$ if exact is FALSE, $N = \frac{e(1 - d)}{2} \ln ((e - de)/\delta)$ otherwise, where $e$ is the number of edges of $g$ and $d$ its edge density. This bound is much lower than the empirical one proposed in Milo et al. 2003 (see References);

accuracy  0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;

verbose  TRUE (default) boolean value. If TRUE print a processing bar during the rewiring algorithm.

MAXITER_MUL  10 (default). If exact=TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;

exact  FALSE (default). If TRUE the program performs max.iter switching steps, otherwise the program will count also the not-performed switching steps;

Details

Performs at most max.iter number of rewiring steps producing a rewired version of an initial undirected graph.

Value

Adjacency matrix of the rewired graph or the relative igraph object depending on the input type.

Author(s)

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>
Special thanks to: Davide Albanese

References


Examples

library(igraph)
library(BiRewire)
g <- erdos.renyi.game(1000, 0.1)
## gets the incidence matrix of g
birewire.sampler.bipartite

Efficient generation of a null model for a given bipartite graph

Description

The routine samples correctly from the null model of a given bipartite graph creating a set of randomized version of the initial bipartite graph.

Usage

birewire.sampler.bipartite(incidence,K,path,max.iter="n", accuracy=0.00005, verbose=TRUE,MAXITER_MUL=10,exact=FALSE,write.sparse=TRUE)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>incidence</td>
<td>Incidence matrix of the initial bipartite graph;</td>
</tr>
<tr>
<td>K</td>
<td>The number of networks that has to be generated;</td>
</tr>
<tr>
<td>path</td>
<td>The directory in which the routine stores the outputs;</td>
</tr>
<tr>
<td>max.iter</td>
<td>&quot;n&quot; (default) the number of switching steps to be performed (or if exact==TRUE the number of successful switching steps). If equal to &quot;n&quot; then this number is considered equal to the analytically derived lower bound presented in Gobbi et al. (see References): $N = e/2(1-d) \ln ((e-de)/d)$ if exact is FALSE, $N = e(1-d)/2 \ln ((e-de)/d)$ otherwise , where $e$ is the number of edges of $g$ and $d$ its edge density . This bound is much lower than the empirical one proposed in Milo et al. 2003 (see References);</td>
</tr>
<tr>
<td>accuracy</td>
<td>0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;</td>
</tr>
<tr>
<td>verbose</td>
<td>TRUE (default). When TRUE a progression bar is printed during computation.</td>
</tr>
<tr>
<td>MAXITER_MUL</td>
<td>10 (default). If exact==TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;</td>
</tr>
<tr>
<td>exact</td>
<td>FALSE (default). If TRUE the program performs max.iter switching steps, otherwise the program will count also the not-performed switching steps;</td>
</tr>
<tr>
<td>write.sparse</td>
<td>TRUE (default). If FALSE the table is written as an R data.frame (long time and more space needed)</td>
</tr>
</tbody>
</table>
**Details**

The routine creates, starting from the given path, different subfolders in order to have maximum 1000 files for folder. Moreover the incidence matrices are saved using `write_stm_CLUTO` (sparse matrices) that can be loaded using `read_stm_CLUTO`. The set is generated calling `birewire.rewire.bipartite` on the last generated graph starting from the input graph.

**Author(s)**

Andrea Gobbi: <gobbi.andrea@mail.com>

**References**


---

**birewire.sampler.dsg**  
Efficient generation of a null model for a given dsg.

**Description**

Efficient generation of a null model for a given dsg. The routine samples correctly from the null model of a given dsg creating a set of randomized dsgs.

**Usage**

```r
birewire.sampler.dsg(dsg,K,path,delimitators=list(negative='-',positive='+'),exact=FALSE, verbose=TRUE, max.iter.pos='n',max.iter.neg='n', accuracy=0.00005,MAXITER_MUL=10)
```

**Arguments**

- `dsg`: A dsg object: is a list of two incidence matrices (see References), "positive" and "negative", encoding the positive edges and negative edges. This list can be obtained reading a SIF file using `birewire.load.dsg` function and converting the resulting dataframe using `birewire.induced.bipartite`.
- `max.iter.pos`: "n" (default) the number of switching steps to be performed on the positive part of `dsg` (or if `exact==TRUE` the number of successful switching steps). If equal to "n" then this number is considered equal to the analytically derived lower bound presented in *Gobbi et al.* (see References): $N = e/(1-d) \ln ((e - de)/\delta)$ if exact is FALSE, $N = e/(1-d)/2 \ln ((e - de)/\delta)$ otherwise , where $e$ is the number of edges of $g$ and $d$ its edge density . This bound is much lower than the empirical one proposed in *Milo et al. 2003* (see References);
max.iter.neg

"n" (default) the number of switching steps to be performed on the negative part of dsg (or if exact=TRUE the number of successful switching steps). If equal to "n" then this number is considered equal to the analytically derived lower bound presented in Gobbi et al. (see References): $N = \frac{e}{2(1 - d)} \ln \left( \frac{(e - de)}{\delta} \right)$ if exact is FALSE, $N = \frac{e(1 - d)}{2} \ln \left( \frac{(e - de)}{\delta} \right)$ otherwise, where $e$ is the number of edges of g and $d$ its edge density. This bound is much lower than the empirical one proposed in Milo et al. 2003 (see References);

accuracy

0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;

verbose

TRUE (default). When TRUE a progression bar is printed during computation.

MAXITER_MUL

10 (default). If exact=TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;

exact

FALSE (default). If TRUE the program performs max.iter switching steps, otherwise the program will count also the not-performed switching steps;

path

The directory in which the routine stores the outputs;

K

The number of network that has to be generated;

delimators

list(negative='-',positive='+') (default):a list with 'positive' and 'negative' names identifying the character encoding the relation used for writing the output with birewire.build.dsg;

Details

The routine creates, starting from a given path, different subfolders in order to have maximum 1000 files for folder; the SIF files are saved using birewire.write.dsg, an internal routine. The set is generated calling birewire.rewire.dsg on the last generated dsg starting from the input dsg.

Author(s)

Andrea Gobbi: <gobbi.andrea@mail.com>

References


birewire.sampler.undirected

Efficient generation of a null model for a given undirected graph

Description

The routine samples correctly from the null model of a given undirected graph creating a set of randomized version of the initial undirected graph.

Usage

birewire.sampler.undirected(adjacency,K,path,max.iter="n", accuracy=0.00005, verbose=TRUE,MAXITER_MUL=10,exact=FALSE,write.sparse=TRUE)

Arguments

- **adjacency**: Adjacency matrix of the initial undirected graph;
- **K**: The number of networks that has to be generated;
- **path**: The directory in which the routine stores the outputs;
- **max.iter**: "n" (default) see birewire.rewire.undirected for references
- **accuracy**: 0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;
- **verbose**: TRUE (default). When TRUE a progression bar is printed during computation.
- **MAXITER_MUL**: 10 (default). If exact=TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;
- **exact**: FALSE (default). If TRUE the program performs max.iter switching steps, otherwise the program will count also the not-performed switching steps;
- **write.sparse**: TRUE (default). If FALSE the table is written as an R data.frame (long time and more space needed)

Details

The routine creates, starting from the given path, different subfolders in order to have maximum 1000 files for folder. Moreover the incidence matrices are saved using write_stm_CLUTO (sparse matrices) that can be loaded using read_stm_CLUTO. The set is generated calling birewire.rewire.undirected on the last generated graph starting from the input graph.

Author(s)

Andrea Gobbi: <gobbi.andrea@mail.com>
birewire.similarity

**References**


---

**birewire.similarity**

*Compute the Jaccard similarity index between two binary matrices with the same number of non-null entries and the same row- and column-wise sums.*

**Description**

Compute the Jaccard similarity index between two binary matrices with the same number of non-null entries and the same row- and column-wise sums. The function accepts also two *igraph* objects.

**Usage**

```r
birewire.similarity( m1,m2)
```

**Arguments**

- `m1`  
  First matrix or graph;
- `m2`  
  Second matrix or graph.

**Details**

The *Jaccard* index between two sets $M$ and $N$ is defined as:

$$\frac{|M \cup N|}{|M \cap N|}$$

With $M$ and $N$ binary matrices, the Jaccard index is computed as:

$$\frac{\sum N_{i,j} \land M_{i,j}}{\sum N_{i,j} \lor M_{i,j}}.$$  

The Jaccard index ranges between 0 and 1.

**Value**

Returns the Jaccard similarity index between the objects.

**Author(s)**

Andrea Gobbi  
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>
Examples

library(igraph)
library(BiRewire)
g <- graph.bipartite(rep(0:1,length=10), c(1:10))
g2 = birewire.rewire.bipartite(g)

birewire.similarity(get.incidence(g,sparse=FALSE),get.incidence(g2,sparse=FALSE))
birewire.similarity(g,g2)

birewire.similarity.dsg

*Compute the Jaccard similarity index between dsg.*

Description

Compute the Jaccard similarity index between dsg objects described in the same way (matrices of graphs).

Usage

birewire.similarity.dsg( m1, m2)

Arguments

- m1: First dsg;
- m2: Second dsg.

Details

See birewire.similarity for more details.

Value

Returns the Jaccard similarity index between the objects.

Author(s)

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>

Examples

library(BiRewire)
data(test_dsg)
dsg <- birewire.induced.bipartite(test_dsg,sparse=FALSE)
birewire.similarity.dsg(dsg,birewire.rewire.dsg(dsg))
dsg <- birewire.induced.bipartite(test_dsg,sparse=TRUE)
birewire.similarity.dsg(dsg,birewire.rewire.dsg(dsg))
birewire.slum.to.sparseMatrix

*The function transforms a triplet sparse matrix from slum package to a Matrix sparse matrix.*

Description

Transform a triplet sparse matrix from *slum* package to a *Matrix* sparse matrix that can be used by *igraph* for creating a network. This function could be used in order to analyze graphs obtained from samplers routines (*birewire.sampler.undirected*, *birewire.sampler.dsg* and *birewire.sampler.bipartite*).

Usage

```r
birewire.slum.to.sparseMatrix( simple_triplet_matrix_sparse)
```

Arguments

- `simple_triplet_matrix_sparse`
  A triplet sparse matrix, usually the object coming from `read_stm_CLUTO`.

Value

Returns an *Matrix* sparse matrix that could be used for building an *igraph* graph using `graph.adjacency`.

Author(s)

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>

birewire.visual.monitoring.bipartite

*Visual monitoring of the Markov chain underlying the SA for directed graphs.*

Description

This function generates a cascade-sampling from the model at different switching steps given in sequence. For each step the routine computes the pairwise Jaccard distance (1-JI) among the samples and performs, on the resulting matrix, a dimensional scaling reduction (using `tsne`). If `display` is set to `TRUE` the relative plot is displayed.

Usage

```r
birewire.visual.monitoring.bipartite(data, accuracy=0.00005, verbose=FALSE, MAXITER_MUL=10, exact=FALSE, n.networks=100, perplexity=15, sequence=c(1,5,100,"n"), ncol=2, nrow=length(sequence)/ncol, display=TRUE)
```
Arguments

- **data**: The initial bipartite graph, either an incidence matrix or an igraph bipartite graph object;
- **accuracy**: 0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;
- **verbose**: TRUE (default). When TRUE a progress bar is printed during computation.
- **MAXITER_MUL**: 10 (default). If `exact==TRUE` in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;
- **exact**: FALSE (default). If TRUE the program performs max.iter switching steps, otherwise the program will count also the not-performed switching steps;
- **n.networks**: 100 (default): the number of network generated for each step defined in sequence;
- **perplexity**: 15 (default): the value of perplexity passed to the function tsne;
- **sequence**: c(1,5,100,"n") (default) the sequence of step for which generating a sampler (see birewire.sampler.bipartite);
- **ncol**: 2 (default). The number of column in the plot;
- **nrow**: length(sequence)/ncol (default). The number of row in the plot;
- **display**: TRUE (default). If TRUE the result is displayed.

Details

For each value \( p \) in sequence (it that can also contain the special character "n", see birewire.rewire.bipartite), the routine generates \( n.networks \) sampled each \( p \) SS from the SA initialized with the given \( data \). Pairwise distance are computed using the Jaccard distance and the resulting matrix is the input for the dimensional scaling performed by the function tsne. An explorative plot is displayed if display is set to TRUE.

Value

A list containing the list containing the distance matrices \( dist \) and the list containing the tsne results \( tsne \).

Author(s)

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>

References


**Examples**

library(BiRewire)
g <- graph.bipartite( rep(0:1,length=100), c(1:100))
birewire.visual.monitoring.bipartite(g,display=FALSE,n.networks=10)

---

**Description**

This function generates a cascade-sampling from the model at different switching steps given in sequence. For each step the routine computes the pairwise Jaccard distance (1-JI) among the samples and performs, on the resulting matrix, a dimensional scaling reduction (using tsne). If display is set to TRUE the relative plot is displayed.

**Usage**

```
birewire.visual.monitoring.dsg(data,accuracy=0.00005,verbose=FALSE,MAXITER_MUL=10,exact=FALSE,n.networks=100,perplexity=15, sequence.pos=c(1,5,100,"n"),sequence.neg=c(1,5,100,"n"),ncol=2,nrow=length(sequence.pos)/ncol,display=TRUE)
```

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data</td>
<td>The initial dsg either in matrix or graph formulation 9see birewire.induced.bipartite.</td>
</tr>
<tr>
<td>accuracy</td>
<td>0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;</td>
</tr>
<tr>
<td>verbose</td>
<td>TRUE (default). When TRUE a progression bar is printed during computation.</td>
</tr>
<tr>
<td>MAXITER_MUL</td>
<td>10 (default). If exact=TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;</td>
</tr>
<tr>
<td>exact</td>
<td>FALSE (default). If TRUE the program performs max.iter switching steps, otherwise the program will count also the not-performed switching steps;</td>
</tr>
<tr>
<td>n.networks</td>
<td>100 (default): the number of network generated for each step defined in sequence;</td>
</tr>
<tr>
<td>perplexity</td>
<td>15 (default): the value of perplexity passed to the function tsne;</td>
</tr>
<tr>
<td>sequence.pos</td>
<td>c(1,5,100,&quot;n&quot;) (default) the sequence of step for which generating a sampler (see birewire.sampler.dsg) for the positive part of data</td>
</tr>
<tr>
<td>sequence.neg</td>
<td>same as sequence.pos but for the negative part</td>
</tr>
<tr>
<td>ncol</td>
<td>2 (default). The number of column in the plot;</td>
</tr>
<tr>
<td>nrow</td>
<td>length(sequence)/ncol (default). The number of row in the plot;</td>
</tr>
<tr>
<td>display</td>
<td>TRUE (default). If TRUE the result of tsne is displayed.</td>
</tr>
</tbody>
</table>
birewire.visual.monitoring.dsg

Details

See birewire.visual.monitoring.bipartite for more details.

Value

A list containing the list containing the distance matrices dist and the list containing the tsne results tsne.

Author(s)

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>

References


Examples

library(BiRewire)
data(test_dsg)
##bigger dsg
test_dsg_2=test_dsg
test_dsg_2[,1]=paste(test_dsg_2[,1],"_",sep="")
test_dsg_2[,3]=paste(test_dsg_2[,3],"_",sep="")
dsg <- birewire.induced.bipartite(rbind(test_dsg,test_dsg_2),sparse=FALSE)
a=birewire.visual.monitoring.dsg(dsg,exact=TRUE,sequence.pos=c(1,2,"n",100),sequence.neg=c(1,2,"n",60),n.networks=50)
Description

This function generates a cascade-sampling from the model at different switching steps given in sequence. For each step the routine computes the pairwise Jaccard distance (1-JI) among the samples and performs, on the resulting matrix, a dimensional scaling reduction (using tsne). If display is set to TRUE the relative plot is displayed.

Usage

birewire.visual.monitoring.undirected(data, accuracy=0.00005, verbose=FALSE, MAXITER_MUL=10, exact=FALSE, n.networks=100, perplexity=15, sequence=c(1,5,100,"n"), ncol=2, nrow=length(sequence)/ncol, display=TRUE)

Arguments

data: The initial undirected graph, either an adjacency matrix or an igraph undirected graph object;

accuracy: 0.00005 (default) is the desired level of accuracy reflecting the average distance between the Jaccard index at the N-th step and its analytically derived fixed point in terms of fraction of common edges;

verbose: TRUE (default). When TRUE a progression bar is printed during computation.

MAXITER_MUL: 10 (default). If exact=TRUE in order to prevent a possible infinite loop the program stops anyway after MAXITER_MUL*max.iter iterations;

exact: FALSE (default). If TRUE the program performs max.iter switching steps, otherwise the program will count also the not-performed switching steps;

n.networks: 100 (default): the number of networks generated for each step defined in sequence;

perplexity: 15 (default): the value of perplexity passed to the function tsne;

sequence: c(1,5,100,"n") (default) the sequence of step for which generating a sampler (see birewire.sampler.undirected);

ncol: 2 (default). The number of column in the plot;

nrow: length(sequence)/ncol (default). The number of row in the plot;

display: TRUE (default). If TRUE the result of tsne is displayed.

Details

For each value p in sequence (it that can also contain the special character "n", see birewire.rewire.bipartite), the routine generates n.networks sampled each p SS from the SA initialized with the given data. Pairwise distance are computed using the Jaccard distance and the resulting matrix is the input for the dimensional scaling performed by the function tsne. An explorative plot is displayed if display is set to TRUE.
Value

A list containing the list containing the distance matrices `dist` and the list containing the tsne results `tsne`.

Author(s)

Andrea Gobbi
Maintainer: Andrea Gobbi <gobbi.andrea@mail.com>

References


Examples

```r
library(BiRewire)
g <- erdos.renyi.game(1000,0.1)
birewire.visual.monitoring.undirected(g,display=FALSE,n.networks=10)
```

Description

Breast cancer samples and their respective mutations downloaded from the Cancer Cancer Genome Atlas (TCGA), used in Gobbi et al. Germline mutations were filtered out of the list of reported mutations; synonymous mutations and mutations identified as benign and tolerated were also removed from the dataset. The bipartite graph resulting when considering this matrix as an incidence matrix has \( n_r = 757, n_c = 9757, e = 19758 \) for an edge density equal to 0.27%.

Usage

```r
data(BRCA_binary_matrix)
```

Source

http://tcga.cancer.gov/dataportal/
References


<table>
<thead>
<tr>
<th>test_dsg</th>
<th>Tool example of dsg</th>
</tr>
</thead>
</table>

Description

A simple dsg for testing routines.

Usage

data(test_dsg)
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