Package 'signnet'

June 30, 2020

Title Methods to Analyse Signed Networks

Version 0.5.3

Description Methods for the analysis of signed networks. This includes several measures for structural balance as introduced by Cartwright and Harary (1956) <doi:10.1037/h0046049>, blockmodeling algorithms from Doreian (2008) <doi:10.1016/j.socnet.2008.03.005>, various centrality indices, and projections of signed two-mode networks introduced by Schoch (2020) <doi:10.1080/0022250X.2019.1711376>.

Depends R (>= 3.2.0)

URL https://github.com/schochastics/signnet

BugReports https://github.com/schochastics/signnet/issues

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Encoding UTF-8

LazyData true

Imports igraph, Rcpp, Matrix

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Suggests testthat (>= 2.1.0), covr, ggplot2, ggraph, knitr, rmarkdown

LinkingTo Rcpp, RcppArmadillo

VignetteBuilder knitr

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R topics documented:

`as_adj_complex` *Convert a signed graph to a complex adjacency matrix*

Description

This function returns the adjacency matrix for a signed graph that contains ambivalent ties

Usage

```
as_adj_complex(g, attr)
```

Arguments

`g`	igraph object
`attr`	edge attribute name that encodes positve ("P"), negative ("N") and ambivalent ("A") ties.

Value

complex adjacency matrix

See Also

as_adj_signed

`as_adj_signed` *Convert a signed graph to a signed adjacency matrix*

Description

This function returns the adjacency matrix for a signed graph

Usage

```
as_adj_signed(g, sparse = FALSE)
```

Arguments

`g`	igraph object. Must have a "sign" edge attribute.
`sparse`	Logical scalar, whether to return the result as a sparse matrix. The Matrix package is required for sparse matrices.

Value

signed adjacency matrix

See Also

as_adj_complex

`as_complex_edges` *Convert Signed Network to Complex*

Description

Convert Signed Network to Complex

Usage

```
as_complex_edges(g, attr = "type")
```

Arguments

`g`	igraph object. Must have a "sign" edge attribute.
`attr`	new edge attribute name that encodes positve ("P"), negative ("N") and ambivalent ("A") ties.

Value

igraph object

Author(s)

David Schoch

Examples

```
g <- sample_islands_signed(2,10,1,10)
as_complex_edges(g)
```

`as_incidence_complex` *Complex Incidence Matrix*

Description

The complex incidence matrix of a signed graph containing ambivalent ties.

Usage

```
as_incidence_complex(g, attr)
```

Arguments

`g`	igraph object.
`attr`	edge attribute name that encodes positve ("P"), negative ("N") and ambivalent ("A") ties.

Details

This function is slightly different than as_incidence_matrix since it is defined for bipartite graphs. The incidence matrix here is defined as a $S \in C^{n,m}$, where n is the number of vertices and m the number of edges. Edges (i,j) are oriented such that i<j and entries are defined as

$$S_{i(i,j)} = \sqrt{A_{ij}}$$

$$S_{j(i,j)} = -\sqrt{A_{ji}} if (i,j) is an ambivalent tie$$

$$S_{j(i,j)} = -A_{ji}\sqrt{A_{ji}} else$$

Value

a complex matrix

Author(s)

David Schoch

See Also

laplacian_matrix_complex,as_adj_complex

`as_incidence_signed` *Convert a signed two-mode network to a signed matrix*

Description

This function returns the incidence matrix for a signed two-mode network.

Usage

```
as_incidence_signed(g, sparse = FALSE)
```

Arguments

`g`	igraph object (bipartite). Must have a "sign" edge attribute.
`sparse`	Logical scalar, whether to return the result as a sparse matrix. The Matrix package is required for sparse matrices.

Value

signed incidence matrix

`as_signed_proj` *convert unsigned projection to signed*

Description

convert unsigned projection to signed

Usage

```
as_signed_proj(g)
```

Arguments

`g`	igraph object

Value

igraph object

Author(s)

David Schoch

See Also

as_unsigned_2mode

Examples

```
library(igraph)

# create a simple signed two mode network
el <- matrix(c(1,"a",1,"b",1,"c",2,"a",2,"b"),ncol = 2,byrow = TRUE)
g <- graph_from_edgelist(el,directed = FALSE)
E(g)$sign <- c(1,1,-1,1,-1)
V(g)$type <- c(FALSE,TRUE,TRUE,TRUE,FALSE)

# convert to unsigned two-mode network and project
l <- as_unsigned_2mode(g,primary = TRUE)
p <- bipartite_projection(l,which="true")

# turn the unsigned projection back to a signed network
as_signed_proj(p)
```

---

as_unsigned_2mode *convert signed two-mode network to unsigned*

Description

convert signed two-mode network to unsigned

Usage

```
as_unsigned_2mode(g, primary = TRUE)
```

Arguments

g	igraph object. Two-mode network, must have a "sign" edge attribute.
primary	logical. Which mode to transform

Value

igraph object

Author(s)

David Schoch

See Also

as_signed_proj

Examples

```
library(igraph)

# create a simple signed two mode network
el <- matrix(c(1,"a",1,"b",1,"c",2,"a",2,"b"),ncol = 2,byrow = TRUE)
g <- graph_from_edgelist(el,directed = FALSE)
E(g)$sign <- c(1,1,-1,1,-1)
V(g)$type <- c(FALSE,TRUE,TRUE,TRUE,FALSE)

# convert to unsigned two-mode network and project
l <- as_unsigned_2mode(g,primary = TRUE)
p <- bipartite_projection(l,which="true")

# turn the unsigned projection back to a signed network
as_signed_proj(p)
```

---

balance_score *balancedness of signed network*

Description

Implements several indices to assess the balancedness of a network.

Usage

```
balance_score(g, method = "triangles")
```

Arguments

g	signed network.
method	string indicating the method to be used. See details for options

Details

The method parameter can be one of

triangles Fraction of balanced triangles. Maximal (=1) if all triangles are balanced.

walk $\sum exp(\lambda_i)/\sum exp(\mu_i)$where λ_i are the eigenvalues of the signed adjacency matrix and μ_i of the unsigned adjacency matrix. Maximal (=1) if all walks are balanced.

frustration The frustration index assumes that the network can be partitioned into two groups, where intra group edges are positive and inter group edges are negative. The index is defined as the sum of intra group negative and inter group positive edges. Note that the problem is NP complete and only an upper bound is returned (based on simulated annealing). Exact methods can be found in the work of Aref. The index is normalized such that it is maximal (=1) if the network is balanced.

Value

balancedness score

Author(s)

David Schoch

References

Estrada, E. (2019). Rethinking structural balance in signed social networks. *Discrete Applied Mathematics*.

Samin Aref, Mark C Wilson (2018). Measuring partial balance in signed networks. *Journal of Complex Networks*, 6(4): 566–595, https://doi.org/10.1093/comnet/cnx044

Examples

```
library(igraph)
g <- graph.full(4)
E(g)$sign <- c(-1,1,1,-1,-1,1)

balance_score(g, method = "triangles")
balance_score(g, method = "walk")
```

---

complex_walks *Count Walks in complex signed network*

Description

Count Walks in complex signed network

Usage

```
complex_walks(g, attr, k)
```

Arguments

g	igraph object.
attr	edge attribute that encodes positve ("P"), negative ("N") and ambivalent ("A") ties.
k	integer. length of walks

Value

igraph object

Author(s)

David Schoch

Examples

```
g <- sample_islands_signed(2,10,1,10)
g <- as_complex_edges(g,attr="type")
complex_walks(g,attr="type",k = 3)
```

`count_complex_triangles` *count complex triangles*

Description

Counts the number of all possible signed triangles (+++),(++-), (+–) and (—)

Usage

```
count_complex_triangles(g, attr)
```

Arguments

`g`	igraph object.
`attr`	edge attribute name that encodes positve ("P"), negative ("N") and ambivalent ("A") ties.

Value

counts for all complex triangle types

Author(s)

David Schoch

See Also

signed_triangles

Examples

```
library(igraph)
g <- graph.full(4)
E(g)$type <- c("P","N","A","A","P","N")
count_complex_triangles(g,attr = "type")
```

count_signed_triangles *count signed triangles*

Description

Counts the number of all possible signed triangles (+++),(++-), (+–) and (—)

Usage

```
count_signed_triangles(g)
```

Arguments

g	igraph object with signed edge attribute

Value

counts for all 4 signed triangle types

Author(s)

David Schoch

See Also

signed_triangles

Examples

```
library(igraph)
g <- graph.full(4)
E(g)$sign <- c(-1,1,1,-1,-1,1)
count_signed_triangles(g)
```

cowList *Signed networks from Correlates of War*

Description

51 signed networks of inter state relations

Usage

```
cowList
```

Format

List of igraph objects

Source

http://mrvar.fdv.uni-lj.si/pajek/SVG/CoW/default.htm

References

Doreian, P. and Mrvar, A. (2015). "Structural Balance and Signed International Relations". *Journal of Social Structure*, 16(2)

---

degree_signed *Signed Degree*

Description

several options to calculate the signed degree of vertices

Usage

```
degree_signed(
  g,
  mode = c("all", "in", "out"),
  type = c("pos", "neg", "ratio", "net")
)
```

Arguments

g	igraph object. Must have a "sign" edge attribute.
mode	character string, “out” for out-degree, “in” for in-degree or “all” for undirected networks.
type	character string, “pos” or “neg” for counting positive or negative neighbors only, "ratio" for pos/(pos+neg), or "net" for pos-neg.

Value

centrality scores as numeric vector.

Author(s)

David Schoch

`eigen_centrality_signed` *Signed Eigenvector centrality*

Description

returns the eigenvector associated with the dominant eigenvalue from the adjacency matrix.

Usage

```
eigen_centrality_signed(g, scale = TRUE)
```

Arguments

`g`	igraph object. Must have a "sign" edge attribute.
`scale`	Logical scalar, whether to scale the result to have a maximum score of one. If no scaling is used then the result vector is the same as returned by `eigen()`.

Details

Note that, with negative values, the adjacency matrix may not have a dominant eigenvalue. This means it is not clear which eigenvector should be used. In addition it is possible for the adjacency matrix to have repeated eigenvalues and hence multiple linearly independent eigenvectors. In this case certain centralities can be arbitrarily assigned. The function returns an error if this is the case.

Value

centrality scores as numeric vector.

Author(s)

David Schoch

References

Bonacich, P. and Lloyd, P. (2004). "Calculating Status with Negative Relations." *Social Networks* 26 (4): 331–38.

Everett, M. and Borgatti, S.P. (2014). "Networks Containing Negative Ties." *Social Networks* 38: 111–20.

Examples

```
library(igraph)
data("tribes")
eigen_centrality_signed(tribes)
```

ggblock *Plot Blockmodel matrix*

Description

Plot Blockmodel matrix

Usage

```
ggblock(
  g,
  blocks = NULL,
  cols = NULL,
  show_blocks = FALSE,
  show_labels = FALSE
)
```

Arguments

g	igraph object. Must have a "sign" edge attribute.
blocks	vector of block membership as obtained, e.g. from signed_blockmodel
cols	colors used for negative and positive ties
show_blocks	logical. Should block borders be displayed? (Default: FALSE)
show_labels	logical. Should node labels be displayed? (Default: FALSE)

Value

ggplot2 object

Author(s)

David Schoch

Examples

```
## Not run:
library(igraph)
data("tribes")
clu <- signed_blockmodel(tribes,k = 3,alpha=0.5,annealing = TRUE)
ggblock(tribes,clu$membership,show_blocks = TRUE,show_labels = TRUE)

## End(Not run)
```

ggsigned *Plot a signed or complex network*

Description

Plot a signed or complex network

Usage

```
ggsigned(g, type = "signed", attr = NULL, edge_cols = NULL, weights = FALSE)
```

Arguments

g	igraph object. Must have a "sign" edge attribute or an attribute containing "P", "N", "A"
type	character string. either "signed" or "complex"
attr	character string. edge attribute that containing "P", "N", "A" if type="complex"
edge_cols	colors used for negative and positive (and ambivalent) ties
weights	logical. If TRUE, weights are computed based on sign. Defaults to FALSE

Details

This is a very rudimentary visualization of a signed network. If you are fluent in 'ggraph', you can probably cook up something more sophisticated. The function is thus mostly meant to give a quick overview of the network.

Value

ggplot2 object

Author(s)

David Schoch

graph_circular_signed *circular signed graph*

Description

circular graph with positive and negative edges.

Usage

```
graph_circular_signed(n, r = 1, pos = 0.1, neg = 0.1)
```

Arguments

n	number of nodes
r	radius
pos	distance fraction between positive edges
neg	distance fraction between negative edges

Value

igraph graph

Author(s)

David Schoch

Examples

```
library(igraph)
graph_circular_signed(n = 50)
```

---

laplacian_angle *Angle between Eigenvectors*

Description

Computes the angle between eigenvectors of the signed or complex Laplacian.

Usage

```
laplacian_angle(g, type = "sign", ...)
```

Arguments

g	input graph. Must have a sign edge attribute
type	string. either "sign" for signed Laplacian or "complex" for complex Laplacian. Defaults to "sign"
...	additional parameters for Laplacian matrix such as the attribute containing "P","N" and "A" for the complex Laplacian

Details

angle between eigenvectors and zero.

Value

a numeric matrix

Author(s)

David Schoch

Examples

```
library(igraph)
g <- sample_islands_signed(3, 10, 5/10, 1)
laplacian_angle(g)
```

---

laplacian_matrix_complex

Complex Graph Laplacian

Description

The Laplacian of a signed graph containing ambivalent ties.

Usage

```
laplacian_matrix_complex(g, attr, norm = FALSE)
```

Arguments

g	igraph object.
attr	edge attribute name that encodes positve ("P"), negative ("N") and ambivalent ("A") ties.
norm	Whether to calculate the normalized Laplacian. See definitions below.

Details

See laplacian_matrix of igraph for more details. In the complex case, D is a diagonal matrix containing the absolute values of row sums of the complex adjacency matrix.

Value

a complex matrix

Author(s)

David Schoch

See Also

laplacian_matrix_signed

`laplacian_matrix_signed` *Signed Graph Laplacian*

Description

The Laplacian of a signed graph.

Usage

```
laplacian_matrix_signed(g, norm = FALSE, sparse = FALSE)
```

Arguments

`g`	igraph object. Must have a "sign" edge attribute.
`norm`	Whether to calculate the normalized Laplacian. See definitions below.
`sparse`	Logical scalar, whether to return the result as a sparse matrix. The Matrix package is required for sparse matrices.

Details

See laplacian_matrix of igraph for more details. In the signed case, D is a diagonal matrix containing the absolute values of row sums of the signed adjacency matrix.

Value

a numeric matrix

Author(s)

David Schoch

Examples

```
library(igraph)
g <- sample_islands_signed(3, 10, 5/10, 1)
laplacian_matrix_signed(g)
laplacian_matrix_signed(g,norm = TRUE)
```

pn_index *PN Centrality Index*

Description

centrality index for signed networks by Everett and Borgatti

Usage

```
pn_index(g, mode = c("all", "in", "out"))
```

Arguments

g	igraph object. Must have a "sign" edge attribute.
mode	character string, “out” for out-pn, “in” for in-pn or “all” for undirected networks.

Value

centrality scores as numeric vector.

Author(s)

David Schoch

References

Everett, M. and Borgatti, S. (2014) Networks containing negative ties. *Social Networks* 38 111-120

Examples

```
library(igraph)
A <- matrix(c(0,  1,  0,  1,  0,  0,  0, -1, -1,  0,
              1,  0,  1, -1,  1, -1, -1,  0,  0,  0,
              0,  1,  0,  1, -1,  0,  0,  0, -1,  0,
              1, -1,  1,  0,  1, -1, -1,  0,  0,  0,
              0,  1, -1,  1,  0,  1,  0, -1,  0, -1,
              0, -1,  0, -1,  1,  0,  1,  0,  1, -1,
              0, -1,  0, -1,  0,  1,  0,  1, -1,  1,
             -1,  0,  0,  0, -1,  0,  1,  0,  1,  0,
             -1,  0, -1,  0,  0,  1, -1,  1,  0,  1,
              0,  0,  0,  0, -1, -1,  1,  0,  1,  0), 10, 10)
g <- igraph::graph_from_adjacency_matrix(A,"undirected",weighted = "sign")
pn_index(g)
```

sample_islands_signed *A graph with random subgraphs conected by negative edges*

Description

Create a number of Erdos-Renyi random graphs with identical parameters, and connect them with the specified number of negative ties.

Usage

```
sample_islands_signed(islands.n, islands.size, islands.pin, n.inter)
```

Arguments

islands.n	The number of islands in the graph.
islands.size	The size of the islands in the graph.
islands.pin	The probability of intra-island edges.
n.inter	number of negative edges between two islands.

Value

a signed igraph graph

Author(s)

David Schoch

Examples

```
library(igraph)
sample_islands_signed(3, 10, 0.5, 1)
```

signed_blockmodel *Blockmodelling for signed networks*

Description

Finds blocks of nodes with intra-positive and inter-negative edges

Usage

```
signed_blockmodel(g, k, alpha = 0.5, annealing = FALSE)
```

Arguments

g	igraph object. Must have a "sign" edge attribute.
k	number of blocks
alpha	see details
annealing	logical. if TRUE, use simulated annealing (Default: FALSE)

Details

The function minimizes P(C)=αN+(1-α)P, where N is the total number of negative ties within plus-sets and P be the total number of positive ties between plus-sets. This function implementes the structural balance model. That is, all diagonal blocks are positive and off-diagonal blocks negative. For the generalized version see signed_blockmodel_general.

Value

numeric vector of block assignments and the associated criterion value

Author(s)

David Schoch

References

Doreian, Patrick and Andrej Mrvar (2009). Partitioning signed social networks. *Social Networks* 31(1) 1-11

Examples

```
library(igraph)

g <- sample_islands_signed(10,10,1,20)
clu <- signed_blockmodel(g,k = 10,alpha = 0.5)
table(clu$membership)
clu$criterion

# Using simulated annealing (less change of getting trapped in local optima)
data("tribes")
clu <- signed_blockmodel(tribes,k = 3,alpha=0.5,annealing = TRUE)
table(clu$membership)
clu$criterion
```

signed_blockmodel_general *Generalized blockmodelling for signed networks*

Description

Finds blocks of nodes with specified inter/intra group ties

Usage

```
signed_blockmodel_general(g, blockmat, alpha = 0.5)
```

Arguments

g	igraph object. Must have a "sign" edge attribute.
blockmat	Integer Matrix. Specifies the inter/intra group patterns of ties
alpha	see details

Details

The function minimizes P(C)=αN+(1-α)P, where N is the total number of negative ties within plus-sets and P be the total number of positive ties between plus-sets. This function implementes the generalized model. For the structural balance version see signed_blockmodel.

Value

numeric vector of block assignments and the associated criterion value

Author(s)

David Schoch

References

Doreian, Patrick and Andrej Mrvar (2009). Partitioning signed social networks. *Social Networks* 31(1) 1-11

Examples

```
library(igraph)
# create a signed network with three groups and different inter/intra group ties
g1 <- g2 <- g3 <- graph.full(5)

V(g1)$name <- as.character(1:5)
V(g2)$name <- as.character(6:10)
V(g3)$name <- as.character(11:15)

g <- Reduce("%u%",list(g1,g2,g3))
```

```
E(g)$sign <- 1
E(g)$sign[1:10] <- -1
g <- add.edges(g,c(rbind(1:5,6:10)),attr = list(sign=-1))
g <- add.edges(g,c(rbind(1:5,11:15)),attr = list(sign=-1))
g <- add.edges(g,c(rbind(11:15,6:10)),attr = list(sign=1))

# specify the link patterns between groups
blockmat <- matrix(c(1,-1,-1,-1,1,1,-1,1,-1),3,3,byrow = TRUE)
res <- signed_blockmodel_general(g,blockmat,0.5)
res$membership
res$criterion
```

`signed_triangles` *list signed triangles*

Description

lists all possible signed triangles

Usage

```
signed_triangles(g)
```

Arguments

g	igraph object with signed edge attribute

Value

matrix of vertex ids and the number of positive ties per triangle

Author(s)

David Schoch

See Also

count_signed_triangles

Examples

```
library(igraph)
g <- graph.full(4)
E(g)$sign <- c(-1,1,1,-1,-1,1)
signed_triangles(g)
```

`tribes` *Signed network of New Guinean highland tribes*

Description

Signed social network of tribes of the Gahuku–Gama alliance structure of the Eastern Central Highlands of New Guinea, from Kenneth Read. The network contains sixteen tribes connected by friendship ("rova") and enmity ("hina").

Usage

```
tribes
```

Format

An igraph object

Source

http://vlado.fmf.uni-lj.si/pub/networks/data/ucinet/gama.dat

References

Read, K. E. (1954) Cultures of the central highlands, New Guinea. *Southwestern Journal of Anthropology*, 1–43.

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