Package ‘multiplex’

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Description Algebraic procedures for the analysis of multiple social networks are delivered with this package as described in Ostoic (2020) <DOI:10.18637/jss.v092.i11>. Among other things, it makes it possible to create and manipulate multiplex, multimode, and multilevel network data with different formats. There are effective ways available to treat multiple networks with routines that combine algebraic systems like the partially ordered semigroup or the semiring structure with the relational bundles occurring in different types of multivariate network data sets. It also provides an algebraic approach for affiliation networks through Galois derivations between families of the pairs of subsets in the two domains.

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Description

One of the aims of the `multiplex` package is to meet the necessity to count with an analytic tool specially designed for social networks with relations at different levels. In this sense, `multiplex` relies on functions to model the local role algebras of the network based on simple and compound relations existing in the system. It also provides a procedure for the construction and analysis of signed networks through the semiring structure, and it is possible to obtain the different relational patterns at the dyadic level in the system, which can serve for further analysis with diverse types of structural theories.

In conjunction with the `multigraph` package, it is possible to visualize multiplex, multimodal, and multilevel structures as graphs or valued graphs.

Details

```
Package: multiplex
Type: Package
Version: 2.9.6
Date: 8 September 2021
License: GPL-3
LazyLoad: yes
```

To work with `multiplex`, we typically start with a specific algebraic structure. A semigroup is a closed system made of a set of elements and an associative operation on it. The semigroup function constructs this algebraic structure, and it takes an array of (usually but not necessarily) multiple binary relations, which are the generator relations. The Word Table and the Edge Table serve to describe the semigroup completely, and they are constructed with the functions `wordT` and `edgeT`, respectively. The `strings` function gives unique relations of the complete semigroup and the `partial.order` function specifies the ordering of the string elements in the semigroup. For the visualization of the partial order structure, the function `diagram` produces the lattice of inclusions of a structure having ordered relations.

Different forms of decomposition that allow reducing semigroups such as factorization or finding congruence classes by substitution and the decomposition is based on congruence with the function `cngr` or π-relation of the unique strings given by `fact` or imported from `Pacnet`. In these two cases, `pi.rels` and `decomp` will do this job for reducing either for an abstract or a partially ordered semigroup structure.

It is also possible to take the attributes of the actors in the analysis of multiple networks with different forms to incorporate this kind of information to the existing relational structures. In this
case, for example, the network exposure of the actors is in the context of multiple networks, or else the resulted algebraic structures can embed the actor attributes.

In addition, it is possible to analyze structural balance in signed networks, which are built by function `signed`, through the algebraic structure of the semiring. A semiring is an algebraic structure that combines an abstract semigroup with identity under multiplication and a commutative monoid under addition. The `semiring` function is capable of performing both balance and cluster semiring either with cycles or with semicycles.

Other capabilities of `multiplex` are not strictly algebraic. For instance, the `dichot` function serves to dichotomize the input data with a specified cut-off value, `rm.isol` removes isolated nodes, and the `perm` function performs an automorphism of the elements in the representative array. All these functions are built for multiple networks represented by high dimensional structures that can be constructed by the function `zbind`.

The `multiplex` package creates a Relation-Box with the `rbox` function to implement the Partial Structural or Compositional Equivalence expressed in the cumulated person hierarchy of the system calculated via the `cph` function. It is from this structure that the partition of multiple networks is possible by counting the multiplicity of their ties.

Relational bundles are identified through the `bundles` function, which provides lists of pair relations. The `transf` function serves to transform such data into a matrix form. The enumeration of the different bundle classes is given by `bundle.census`. An advantage of counting with the bundle patterns is that the different types of bundles serve to establish a system inside the network, in which it is possible to measure the network exposure in multivariate relational systems. Such features can be realized via the `rel.sys` and `expos` functions, respectively. Several attributes can be derived by `galois`, which provides an algebraic approach for two-mode networks.

Finally, multivariate network data can be created through the `(s)end (r)eceive (t)ies format that can be loaded and transformed via the `read.srt` function. Other formats for multiple network data like `Ucinet dl` or `Visone gml` can be imported and exported as well with the `multiplex` package.

Author(s)

J. Antonio Rivero Ostoic

Maintainer: Antonio Rivero Ostoic <multiplex@post.com>

References


Ostoic, J.A.R. ‘Algebraic Analysis of Multiple Social Networks with `multiplex`.’ *Journal of Statistical Software*, 91(11), 1-41. <doi:10.18637/jss.v092.i11>

See Also

`multigraph`
Examples

## Create the data: two binary relations among three elements
arr <- round(replace(array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2))>.5, 3 ))

## Dichotomize it with customized cutoff value
dichot(arr, c = 3)

## preview
prev(arr)

## create the semigroup (elay...)
semigroup(arr)

## and look at the strings
strings(arr)

---

as.semigroup | **Coerce to a Semigroup Object**

Description

A generic function for coercing an R object to a semigroup class.

Usage

as.semigroup(x, gens = NA, lbs, numerical, edgeT)

Arguments

- **x**: an array representing the semigroup
- **gens**: array or vector representing the semigroup generators
- **lbs**: (optional) label strings for the semigroup
- **numerical**: (optional and logical) should the semigroup have numerical format?
- **edgeT**: (optional, logical, and experimental) is ‘x’ an edge table?

Details

Since many of the functions in the multiplex package require an object of the ‘Semigroup’ class, this function produces this class object from an array representing the semigroup structure.
as.signed

Value
An object of the ‘Semigroup’ class

ord a number with the dimension of the semigroup
st the strings, i.e. a vector of the unique relations
gens the semigroup generators
S the multiplication table of the semigroup

Author(s)
Antonio Rivero Ostoic

See Also
semigroup

Examples
## create labeled multiplication table data
s <- matrix(data=c(1, 1, 3, 3, 3, 3, 3, 3, 3), nrow=3, ncol=3, byrow=TRUE)
attr(s, "dimnames") <- list(1:3,1:3)

## make a semigroup object
as.semigroup(s)

as.signed Coerce to a Signed Object

Description
A generic function for coercing an object to a Signed class.

Usage
as.signed(x, lbs)

Arguments
x a matrix representing the signed network
lbs (optional) labels for the signed matrix

Details
Since the semiring function requires an object with a ‘Signed’ class, this function produces this class object from an array representing the signed network
as.strings

Value

The array as a Signed class

See Also

signed, semiring

Examples

```r
## Load the data
data("incubA")

## Coerce parts of the signed matrix with two types of relations
as.signed(signed(incubA$IM)$s[1:2,1:2])
```

---

**as.strings**

*Coerce an Object to a Strings Class*

**Description**

A generic function for coercing an R object to a Rel.Strings class.

**Usage**

```r
as.strings(x, lbs = NULL)
```

**Arguments**

- `x`: an array; usually with three dimensions of stacked matrices where the multiple relations are placed.
- `lbs`: (optional) the labels of the strings

**Details**

This function is useful to proceed with the establishment of the partial order in the strings of relations where the object should be of a ‘Strings’ class.

**Value**

An object of ‘Strings’ class

- `wt`: the word tables
- `ord`: the number of unique relations in the semigroup

**Author(s)**

Antonio Rivero Ostoic
See Also

strings, partial.order, zbind

Examples

```r
## Create the data: two sets with a pair of binary relations among
## three elements
arr1 <- round( replace( array(runif(18), c(3,3,2)), array(runif(18),
c(3,3,2))>.5, 3 ) )

arr2 <- round( replace( array(runif(18), c(3,3,2)), array(runif(18),
c(3,3,2))>.5, 3 ) )

## bind the data sets
arrs <- zbind(arr1, arr2)

## make the data a strings object
as.strings(arrs)
```

bundle.census

**Bundle Census**

Description

A function to perform the Bundle Census in multiple networks.

Usage

```r
bundle.census(x, loops = FALSE)
```

Arguments

- `x` an array; usually with three dimensions of stacked matrices where the multiple relations are placed.
- `loops` (logical) whether or not the loops should be considered

Details

This function calculates the number of occurrences for each bundle class pattern in multiple networks. A bundle is a particular type of pattern made of relations at different levels that is binding a pair of nodes or actors. Depending on the direction and occurrence of each possible tie, then it is possible to count with seven dyadic configuration classes in the census.
Value

A table with the occurrences in the distinct bundle class patterns. The first column in the output gives the number of bundles in the network, excluding the null pattern, and then the totals for each bundle class pattern are specified in the following columns. The last column of the table hosts loops in case these are activated in the input.

Functions bundles and summaryBundles provide bundle class occurrences in the network with a more detailed information.

Author(s)

Antonio Rivero Ostoic

References


See Also

bundles, summaryBundles

Examples

## Create the data: two binary relations among three elements
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18),
c(3,3,2))>.8, 3 ) )

## Calculate the Bundle Census
bundle.census(arr)

<table>
<thead>
<tr>
<th>bundles</th>
<th>Bundle Class Patterns</th>
</tr>
</thead>
</table>

Description

Classify the Bundle class patterns in a system of multiple relations

Usage

bundles(x, loops = FALSE, smpl = FALSE, lb2lb = TRUE, collapse = FALSE, sep)
Arguments

- **x**: an array; usually with three dimensions of stacked matrices where the multiple relations are placed.
- **loops**: (logical) whether or not the loops should be considered as a particular bundle.
- **smpl**: (logical) simplify the strings of relations? Default no.
- **lb2lb**: (logical) should the labels of the nodes be included in the output? (default yes).
- **collapse**: (logical) collapse the distinct levels of relations in the network? (default yes).
- **sep**: (optional) the pair separator for the pairwise relations.

Details

A bundle is a particular type of pattern made of relations at different levels that is binding a pair of nodes or actors in a network of relationships. A bundle class is a dyadic configuration resulting from the mixture of the direction and the types of ties between the nodes or actors. There are in total seven dyadic configuration classes, which are `null`, `asymmetric`, `reciprocal`, `tie entrainment`, `tie exchange`, `mixed`, and the `full` bundle pattern. This function provides detailed information about the bundle class patterns in multiple networks as lists of pair relations among the nodes or actors, except for the ‘null’ pattern.

In case that the nodes are not labeled, then an identification number will be assigned according to the nodes’ location in the array representation and as well when the `lb2lb` option is set to `FALSE`. This function assumes that the network is directed, and self ties can also be considered in the output.

Long string labels can be simplified with `smpl`, whereas the `collapse` option blurs the levels in the strings.

Value

An object of `Rel.Bundles` class with the distinct bundle class patterns.

- **asym**: asymmetric
- **recp**: reciprocal
- **tent**: tie entrainment
- **txch**: tie exchange
- **mixed**: mixed
- **full**: full
- **loops**: loops (if chosen)

Note

The input array for this function is always dichotomized, and it is possible to obtain the total number of occurrences in each bundle class pattern with the `bundle.census` function.

Author(s)

Antonio Rivero Ostoic
cngr

References

See Also
bundle.census, summaryBundles, transf.

Examples
```r
## Create the data: two binary relations among three elements
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18),
c(3,3,2))>.8, 3 ) )

## Establish the different bundles
bundles(arr)
```

cngr

Congruence Relations

Description
Find the congruence relations of a given abstract or a partially ordered semigroup.

Usage
cngr(S, PO = NULL, uniq)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>an object from the ‘Semigroup’ class.</td>
</tr>
<tr>
<td>PO</td>
<td>(optional) the partial order table</td>
</tr>
<tr>
<td>uniq</td>
<td>(optional and logical) whether or not return the unique congruence relations</td>
</tr>
</tbody>
</table>

Details
Congruencies are equivalence relations that preserve the operation between the correspondent classes in the algebraic structure. In this case, the different congruence classes are based on the substitution property of the semigroup object.

Value
An object of ‘Congruence’ class. The items included are:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>semigroup of relations</td>
</tr>
<tr>
<td>PO</td>
<td>partial order table (if specified)</td>
</tr>
<tr>
<td>clu</td>
<td>congruence classes</td>
</tr>
</tbody>
</table>
Note

If the partial order is supplied in the input, then the computation of the congruence classes is slightly faster than for an abstract semigroup.

Author(s)

Antonio Rivero Ostoic

References


See Also

decomp, fact, pacnet

Examples

```r
## Create an abstract semigroup object
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2))>.5, 1 )
# S <- semigroup(arr)

## look at the congruences in S
cngr(S, PO=NULL)
```

---

comps | *Find components in multiple networks*

Description

Function to find different components in the multiple network including isolates.

Usage

```r
comps(x, bonds = c("entire", "strong", "weak"))
```

Arguments

- `x` array representing the network
- `bonds` the type of bonds to be used in the creation of the relational system for the different components

Details

The network’s different components are obtained through the transitive closure of the bundle ties. By default, the “entire” system is chosen, but the option bonds allow discriminating different types of relational bundles for the components.

Value

A list with two possible “components”

<table>
<thead>
<tr>
<th>com</th>
<th>a component</th>
</tr>
</thead>
<tbody>
<tr>
<td>isol</td>
<td>the isolates</td>
</tr>
</tbody>
</table>

Author(s)

Antonio Rivero Ostoic

See Also

bundles, rel.sys

Examples

```r
## Create the data: two binary relations among three elements
arr <- round( replace( array( runif(18), c(3 ,3, 2) ), array( runif(18),
 c(3, 3, 2) ) > .9, 3 ) )

## Find components ans isolates
comps(arr)
```

---

**cph**

*Cumulated Person Hierarchy*

Description

A function to calculate the Cumulated Person Hierarchy in networks of multiple relations

Usage

```
cph(W, lbs)
```

Arguments

<table>
<thead>
<tr>
<th>W</th>
<th>an object of the ‘Rel.Box’ class.</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbs</td>
<td>(optional) the labels of the relational system</td>
</tr>
</tbody>
</table>
Details

The cumulated person hierarchy is used to determine the partial structural equivalence among the actors in a multiple network. Two nodes are considered as *partial structural equivalent* iff they have identical role sets.

The outcome of this function depends on the characteristics of the Relation-Box.

Value

An object of ‘Partial.Order’ class with an array representing the cumulated person hierarchy.

Note

If the length of the labels differs from the order of the relational system, then labels will be ignored.

Author(s)

Antonio Rivero Ostoic

References


See Also

rbox, semigroup, diagram

Examples

```r
## load the data
data("incubA")

## Make the Relation Box of the image matrices
rb <- rbox(incubA$IM)

## Calculate the cumulated person hierarchy
cph(rb)
```
decomp

**Decomposition of a Semigroup Structure**

**Description**
A function to perform the decomposition of a semigroup structure

**Usage**
```r
decom(S, pr, type = c("mca", "pi", "at", "cc"), reduc, fac, force)
```

**Arguments**
- `S`: an object of a ‘Semigroup’ class
- `pr`: either an object of a ‘Congruence’ class or an object of a ‘Pi.rels’ class
- `type`: whether the reduction is based on a congruence class (option "cc") or rather on a π-relation ("pi"), atoms (option "at"), or a meet-complement of atoms (option "mca") in the ‘Pi.rels’ class
- `reduc`: (optional and logical) does the return object should include the reduced structures?
- `fac`: (optional) the factor that should be decomposed
- `force`: (optional and logical) force further reduction of the semigroup when S has NAs? (see details)

**Details**
The `decomp` function performs a reduction of an algebraic structure like the semigroup that verifies which of the class members in the system are congruent to each other. The decomposed object then is made of congruent elements, which form part of the lattice of congruence classes in the algebraic structure. In case that the input data comes from the Pacnet program, then such elements are in the form of π-relations or the meet-complements of the atoms. Otherwise, these are simply equivalent elements satisfying the substitution property.

Sometimes a ‘Semigroup’ class object contains not available data in the multiplication table, typically when it is an image from the `fact` function. In such a case, it is possible to perform a reduction of the semigroup structure with the `force` option, which performs additional equations to the string relations in order to get rid of NAs in the semigroup data.

**Value**
An object of ‘Decomp’ class having:
- `clu`: vector with the class membership
- `eq`: the equations in the decomposition
- `IM`: (optional) the image matrices
- `PO`: (optional) the partial order table
- `ord`: (optional) a vector with the order of the image matrices
Note

Reduction of the partial order table should be made by the `reduc` function.

Author(s)

Antonio Rivero Ostoic

References


See Also

`fact`, `cngr`, `reduc`, `pi.rels`, `semigroup`, `partial.order`

---

**Diagram**

**Plot a Hasse Diagram of a set of ordered relations**

Description

A function to plot a Hasse Diagram of partially ordered relations.

Usage

```r
diagram(x, attrs = NULL, main = NULL, incmp, cex.main, bg, mar, shape,
         col, col0, fcol, ecol, lty, lbs, ffamily, fstyle, fsize, col.main,...)
```

Arguments

- **x**: a matrix representing ordered relations
- **attrs**: (optional) attributes of the diagram
- **main**: (optional) title of the diagram
- **incmp**: (optional and logical) whether or not the incomparable elements should be included in the lattice diagram
- **cex.main**: (optional) size of the diagram’s title
- **bg**: (optional) the background color of the diagram
- **mar**: (optional) the margins of the plot
- **shape**: (optional) the shape of the vertices
- **col**: (optional) the color of the vertices
- **col0**: (optional) the color of the vertices’ contour
- **fcol**: (optional) the color of the text’s vertices
- **ecol**: (optional) the color of the edges
An example of ordered relations is found in the partial order table of relations, which is product of the 'strings' option in the `partial.order` function. Another set of ordered relations comes from the table produced on Galois derivations in the mentioned function.

In either case this function plot either the partial order or a linear order diagram, depending on the results as Hasse diagrams.

Value

A Hasse diagram of the partial order relation.

Warning

This function requires that the `Rgraphviz` package is available.

Note

Note that if the elements of the partial order are not labelled, Roman numerals will be given to each element.

Author(s)

Antonio Rivero Ostoic

See Also

`partial.order`, `as.strings`, `strings`, `diagram.levels`, `galois`.

Examples

```r
## load the data
data("incubA")

## given e.g. a partial order table in the object 'po'
po <- partial.order(as.strings(incubA$IM), type="strings")

## plot the order relation as a Hasse diagram.
## Not run: if(require(Rgraphviz)) {
plot(diagram(po))
```
diagram.levels

Levels in the Lattice Diagram

Description

This function reads the different levels in the lattice diagram of the partial order structure among actors and ties in the network.

Usage

diagram.levels(x, perm = FALSE)

Arguments

x
A matrix representing the partial order

perm
(optional) whether or not to return the permuted structure

Details

When it comes to reduce the structure of a multiple network, many times the partial order structure provides different classes of elements depending in the inclusions these elements have. In this sense, the illustration given by the diagram function provides us typically with different levels of the ordered relations, which are read by this routine.

Value

A data frame with the elements of the partial order structure with the column names indicating the element class. If the permutation is specified, then a vector with the levels and a matrix with the permuted structure are given as well.

Note

This function requires that the Rgraphviz package is available. Besides, since the pictex function from grDevices is inside this routine, it implies counting with administrator privileges for running.

Author(s)

Antonio Rivero Ostoic

See Also

partial.order, diagram, perm
dichot

Examples

```r
## load the data
data("incubA")

## given e.g. a partial order table in the object 'po'
po <- partial.order(as.strings(incubA$IM))

## find the levels in the lattice diagram
## Not run: diagram.levels(po)
```

---

**dichot**

*Dichotomize data with a cutoff*

**Description**

Function to dichotomize the input data for the semigroup construction with a cutoff value.

**Usage**

```r
dichot(x, c = 1, diag)
```

**Arguments**

- `x` some data in a numeric form (usually arrays)
- `c` the cutoff value to perform the dichotomization (default 1)
- `diag` (optional and logical) whether or not the diagonals should be included (default TRUE)

**Details**

This is a convenient function (or wrapper if you like) of the `replace` function. In this case the function is aimed to specify a cutoff value for the dichotomization of the data where the values equal or higher to the cutoff are converted to one, while the others are set to zero. The cutoff can be any real number.

**Value**

Binary values of the input data.

**Note**

The labels are preserved after the dichotomization.

**Author(s)**

Antonio Rivero Ostoic
See Also

replace, prev, semigroup.

Examples

```r
## Create the data: 2 binary relations among 3 elements
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18),
                         c(3,3,2))>.5, 3 ) )

## dichotomize it with a cutoff value of 2
dichot(arr, c = 2)
```

edgeT

Edge Table Generator

Description

The Edge Table generator of multiple relations.

Usage

dedgeT(x)

Arguments

x 
an array; usually with three dimensions of stacked matrices where the multiple relations are placed.

Details

The Edge Table is the complete right multiplication table of the semigroup having its elements for each of its generators.

Value

An object of the ‘EdgeTable’ class
gens 
the generator relations
ET 
the Edge Table

Author(s)

Antonio Rivero Ostoic

References

See Also

`wordT`, `semigroup`.

Examples

```r
## Create the data: 2 binary relations among 3 elements
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2))>.5, 1 ) )

## get the edge table
edgeT(arr)
```

---

**expos**

*Network Exposure for Multiple Networks*

Description

Function to measure the network exposure of the nodes according to a chosen relational system representing the multiple network.

Usage

```r
expos(rs, classes = FALSE, allClasses = FALSE, allNodes = TRUE)
```

Arguments

- `rs`: an object of `Rel.System`, typically with node attributes.
- `classes`: (optional) whether or not should be included in the output the categories of adopters
- `allClasses`: (optional) whether or not to include empty classes within the categories of adopters. Ignored if `classes` is `FALSE`
- `allNodes`: (optional) whether or not to include all actors in the network regardless they are in the chosen system. Ignored if `classes` is `FALSE`

Details

This is a generalization of the network exposure measure for multiple networks with the characteristics chosen for the representative relational system. Such system can be the entire network or configuration with strong or weak bonds among the actors. It is possible to specify different behaviors of the nodes representing social actors, which are indicated in the form of a relational system. The network exposure measure is calculated according to the immediate neighbors to the reference actor.
Value

Classes  if `classes` is set to `TRUE`, the adoption membership for the type of relational system chosen, including isolated actors in the system.

Bonds  the type of bonds of the relational system (cf. `rel.sys`)

Exposure  the exposure to the attribute(s) for acquisition through immediate neighbour relations

Author(s)

Antonio Rivero Ostoic

References


See Also

`rel.sys`, `neighb`, `bundles`

Examples

```r
## Create the data: two binary relations among three elements
arr <- round( replace( array( runif(18), c(3 ,3, 2) ), array( runif(18), c(3, 3, 2) ) > .9, 3 ) )

## the first array is for attributes
rs <- rel.sys(arr, att = 1)

## Calculate the exposure measure for an attribute type with adopter categories
expos(rs, classes = TRUE)
```

fact  Factorization of semigroup structures

Description

A function to decompose partially ordered semigroups

Usage

```r
fact(S, P, uniq = TRUE, fac, atoms, mca, atmc, patm, k)
```
Arguments

- **S**: a semigroup object, \( S \)
- **P**: a partial order structure associated to \( S \)
- **uniq**: (logical) whether the factorization include the unique induced inclusions
- **fac**: (integer) the ‘factor’ to be factorized (see details)
- **atoms**: (logical) whether or not include the atoms in the output
- **mca**: (logical) whether or not include the meet-complements of atoms in the output
- **atmc**: (logical) whether or not include the atoms’ meet-complements in the output
- **patm**: (logical) whether or not include the potential atoms in the output
- **k**: the length of the induced inclusion (only relevant if \( patm \) is activated)

Details

The factorization is part of the decomposition process for partially ordered semigroups, which means that there are two objects in the input. The induced inclusions are additions to the partial order and, depending on the needs; it is possible to customize the rest of the output. Atoms and meet-complement of these are useful for the decomposition through the `decomp` that produce a number of reduced structures or ‘factors’. Argument \( fac \) allows choosing a factor for a progressive factorization.

Value

An object of "Ind.incl" class having:

- **po**: the partial order table
- **iin**: list of induced inclusions pairwise listed
- **niin**: length of the induced inclusion
- **patm**: (optional) a vector with the potential atoms
- **atm**: (optional) a vector with the atoms
- **atmc**: (optional) array with meet-complements of atoms
- **mca**: (optional) meet-complements of atoms
- **note**: (optional) induced inclusions without the substitution property

Author(s)

Antonio Rivero Ostoic (based on the algorithm described in Ardu, 1995)

References


See Also
decomp, cngr, pacnet

Examples

## Create a partially ordered semigroup
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2))>.5, 1 ) )
# semigroup
S <- semigroup(arr)
# string relations
St <- strings(arr)
# partial order
P <- partial.order(St)

## Perform the factorisation of PO S
fact(S, P)

---

fltr | Principal filters

Description

A function to find principal filters in a partial order

Usage

fltr(x, PO, ideal = FALSE, rclos)

Arguments

x | the reference element in the partial order (integer or character)
PO | the partial order
ideal | (logical) whether or not the “filter” is an ideal
rclos | (optional and logical) apply reflexive closure?

Details

This function helps to find principal filters or principal ideals for an element in a partial order structure. Such inputs are normally a concept or an object or attribute in the concept together with the associated partial ordering structure of the concepts, which results from Galois derivations. Typically, if the reference element refers to a concept, then it is given as a positive integer indicating the concept label. Another option is to refer an object or an attribute by a character name, which should be part in the labels of the dimensions of the partial order table with a reduced labeling. Principal filters with a full labelling are not allowed if the reference element is an object or an attributes. Use an integer for the concept instead.
**Value**
A named list with the elements in the upset or downset of the principal filter or ideal corresponding to the reference element in the partial order.

**Author(s)**
Antonio Rivero Ostoic

**References**

**See Also**
galois, partial.order, diagram.

**Examples**
```r
## Create a data frame
dfr <- data.frame(x=1:3, y=5:7)

## Partial ordering of concepts
PO <- partial.order(galois(dfr),"galois")

## Filter for the first element
fltr(1, PO, rclos=TRUE)
```

---

**galois**

*Galois derivations between subsets*

**Description**
Function to perform Galois derivations between partially ordered subsets

**Usage**
galois(x, labeling = c("full", "reduced"), sep, valued, scl, sep2)

**Arguments**
x
labeling
sep
valued
scl
sep2

---

A data frame with objects and attributes
whether the derivations should be with full or reduced labeling
(optional) the pair separator for the pairwise relations
(logical) whether the galois derivation is on a many-valued formal context
(optional, only for valued) the scale to be used in the galois derivation
(optional, only for valued) the separator in the formal concept
Details
Galois derivations (or connections) are mappings between families of partially ordered subsets of elements. Such derivations are useful to analyze the structure of both subsets, which in a social network are typically the actors and their corresponding affiliations or events. That is, two-mode networks, but also a group of objects with a list of different attributes as used in formal concept analysis.

Value
A labelled list with Galois derivations of objects and attributes

Note
Full labeling implies first objects and then attributes, whereas the reduced option is given the other way around.

Author(s)
Antonio Rivero Ostoic

References

See Also
partial.order, diagram, fltr.

Examples
```r
## Create a data frame
dfr <- data.frame(x=1:3, y=5:7)

## Find Galois derivations
galois(dfr)
```

Description
A function to establish either the Person or the Relation Hierarchy in a multiple network

Usage
```r
hierar(W, x, type = c("person", "relation"))
```
Arguments

\( \mathcal{W} \)

an object of ‘Rel.Box’

\( x \)

(integer or character) the actor of reference, either by its location in the adjacency matrix or by the label.

\( \text{type} \)

whether the hierarchy is for the ‘persons’ or for the ‘relations’ in the network with respect to ‘\( x \)’

Details

The person hierarchy refers to the inclusion relations among the actors, whereas the relation hierarchy refers to the inclusion relations among the ties. Both are from the perspective of a chosen actor of reference in the given network.

Value

An array that represents the partial order structure of the respective hierarchy.

Note

The cumulative person hierarchy is obtained through the \( \text{cph} \) function.

Author(s)

Antonio Rivero Ostoic

References


See Also

\( \text{rbox, cph, partial.order, diagram} \)

Examples

```r
## Create the data: 2 binary relations among 3 elements
arr <- round( replace( array( runif(18), c(3 ,3, 2) ), array( runif(18), c(3, 3, 2) ) > .5, 3 ) )

## The relation box
rarr <- rbox(arr, k=1)

## Calculated the person hierarchy of a random actor
hierar(rarr, ceiling(runif(1, min=0, max=dim(arr)[2])))
```
**Incubator networks dataset**

**Description**

These are four data sets collected in year 2010 (see ‘source’ for the details) of multiple relations between entrepreneurial firms working in business incubators in Denmark.

Each data set contains the adjacency matrices of the three social relations, coded as C, F, and K for working collaboration, informal friendship, and perceived competition among the firms. There are also two actor attributes corresponding to adoption of two Web innovations in year 2010 by the firms where A stands for Linkedin, and B for Facebook.

In addition, there is a blockmodel attached to each data set that is product of Compositional Equivalence (cf. cph) with transposes for each type of social tie labelled with the following letter in the Latin alphabet; i.e. D for collaboration, G for friendship, and L for perceived competition.

**Usage**

```r
data("incubs")
data("incubA")
data("incubB")
data("incubC")
data("incubD")
data("incA")
data("incB")
data("incC")
data("incD")
```

**Format**

Each data set is a list with a pair of three dimensional arrays.

For `incubA`, the dimensions of `net` are $26 \times 26 \times 5$, and of `IM` are $4 \times 4 \times 7$ (the two attributes led to the identity matrix).

For `incubB`, the dimensions of `net` are $18 \times 18 \times 5$, and of `IM` are $4 \times 4 \times 8$.

For `incubC`, the dimensions of `net` are $22 \times 22 \times 5$, and of `IM` are $3 \times 3 \times 8$.

For `incubD`, the dimensions of `net` are $15 \times 15 \times 5$, and of `IM` are $4 \times 4 \times 6$.

All four networks are putted in together in `incubs`.

In order to plot automatically actor attributes in the graph with function `multigraph`, another version of these data sets are given in `incA`, `incB`, `incC`, and `incD`, which are "Data.Set" objects class having:

- `net` for the network data
- `atnet` a vector that indicates whether or not the arrays in 'net' is attribute data
- `IM` for the Image Matrices of the reduced network data
- `atIM` a vector that indicates whether or not the array in 'IM' is attribute data
- `cite` relational content of the ties
mlvl

Source
Ostoic, J.A.R. ‘Algebraic methods for the analysis of multiple social networks and actors attributes’

mlvl Constructing multilevel structures

Description
Function to create a multilevel structure from a one- and a two-mode network.

Usage
mlvl(x = NULL, y = NULL, type = c("bpn", "cn", "cn2", "list"),
     symCdm, diag, lbs)

Arguments
x the domain data
y the codomain data
type the type of multilevel structure
symCdm (optional and logical, only for bpn) whether or not symmetrize the codomain structure
diag (optional and logical) whether or not include the entries in the diagonal matrices
lbs (optional, only for cn2) tie labels

Details
The default multilevel structure is bpn that requires data for the two domains. However, option cn does need x since returns the co-affiliation network of the codomain structure.
Many times is convenient to specify the domain and codomain labels, and since these are different components in the multilevel structure, then the labels have to be specified as a list object.

Value
An object of ‘Multilevel’ class of chosen type.

mlnet the multilevel network
lbs (list) domain and codomain labels
modes a vector indicating the domain of the data in mlnet where 1M is for domain and 2 is for the codomain.

Author(s)
Antonio Rivero Ostoic
See Also

multigraph

**mnplx**

*Make a multiple network as monoplex structure*

**Description**

A function to transform multiple networks into a monoplex structure

**Usage**

`mnplx(net, directed = TRUE, dichot, diag, clu)`

**Arguments**

- `net` a three-dimensional array to be transformed into a matrix
- `directed` (optional) whether to make the matrix symmetric or not
- `dichot` (optional) should the output be dichotomized?
- `diag` (optional) should the diagonals be included?
- `clu` (optional) a vector with the cluster for the permutation

**Details**

With this function, it is possible to collapse multiple types of tie into a matrix representation with monoplex relations.

**Value**

A matrix of monoplex relations

**Author(s)**

Antonio Rivero Ostoic

**See Also**

`zbind, dichot, reduc`

**Examples**

```r
## Create the data: 2 binary relations among 3 elements
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2))>.5, 1 ) )

## Make it monoplex
mnplx(arr)
```
Description

A function to find the neighborhood of an actor or group of actors with a customized distance.

Usage

neighb(x, rs, type = c("und", "inn", "out"), k = 1, inclx = FALSE, expand)

Arguments

- **x**: the reference actor labeled in rs or a vector of several actors
- **rs**: the relational system of the network
- **type**: whether the network is undirected (default) und; directed with incoming node’s ties inn to the the reference actor, or else with outgoing arcs out
- **k**: the “distance” of the neighbor nodes to the reference actor (where k=1 gives the adjacent nodes)
- **inclx**: (logical) should the reference actor be included in the output?
- **expand**: (optional and logical) should the output be given by k (it only makes sense when k>1)

Details

The relational system serves to represent either the entire multiple network, or else just the relational bundles having a mutual or an asymmetric character. In this sense, this function detects the adjacent nodes to x according to the specified relational system, but as well the neighbors of the adjacent nodes with a customized length. Eventually, when the longest path or chain is reached, adding more value to k obviously will not produce more nodes in the graph system.

Value

Depending on expand, the output is either a vector or a list with the neighbor nodes to the reference actor(s).

Note

In case that the reference actors are in different components of the network, the output does not discriminate this fact.

Author(s)

Antonio Rivero Ostoic
See Also

expos, rel.sys, bundles

Examples

```r
## Create the data: two binary relations among three elements
arr <- round(replace(array(runif(18), c(3, 3, 2)),
                      array(runif(18),
                             c(3, 3, 2)) > .9, 3))

## Determine the system of strong bonds
rs <- rel.sys(arr, bonds = "strong")

## the immediate neighbourhood of the first node
neighb(1, rs)
```

pacnet

Read Output from Pacnet

Description

A function to read output files from the Pacnet program with the full factorization option.

Usage

```r
pacnet(file, toarray = FALSE, uniq = FALSE,
       transp = FALSE, sep)
```

Arguments

- `file` character vector containing a file name or path
- `toarray` (logical) should the induced inclusions be transformed into arrays?
- `uniq` (logical) should only be considered the induced inclusions that are unique?
- `transp` (logical) should the partially ordered structures be transposed?
- `sep` (optional) the pair separator for the pairwise relations

Details

This function is used to read the output file from the Pacnet program, which typically has the .out extension. By default the result is given in a list format, but it is possible to transform the pair lists into arrays. Note that the options in the Pacnet program should include the full factorization in the output; otherwise the object will be NULL.
**Value**

An object of the ‘Pacnet’ class with items:

- `ii` induced inclusions
- `at` atoms
- `mc` meet complements

**Note**

Currently only partial order structures of order 36 and less are supported.

**Author(s)**

Antonio Rivero Ostoic

**References**


**See Also**

`pi.rels`, `cngr`, `decomp`, `write.dat`

---

**Description**

Construct the partial order table of unique relations of the semigroup, or else of the concepts produced by Galois derivations.

**Usage**

```r
partial.order(x, type = c("strings", "galois", "pi.rels"),
             lbs, sel, po.incl, dichot)
```

**Arguments**

- `x` an object of a ‘Strings’ or a ‘Galois’ class
- `type` whether the object corresponds to string relations, Galois derivations, or π-relations
- `lbs` (optional) the labels of the unique relations
- `sel` (optional) selected elements in ‘x’ for the partial order
- `po.incl` (optional, works only with type "pi.rels") should the partial order in the π-relations be included
- `dichot` (optional) should the string relations in x be dichotomized?
Details

To get the partial order of an entire semigroup, both generators and compound relations must be considered. This information and the labels of the unique relations are given by the strings function. cf. semigroup to see how the x should be specified properly.

Galois derivations are now possible to be partially ordered as well, and this option is based on the output given by the galois function.

Value

An object of 'Partial.Order' class with the partial order table in a matrix form.

Author(s)

Antonio Rivero Ostoic

References


See Also

as.strings, strings, galois, perm, diagram, fltr.

Examples

```r
## Load the data, and obtain the partial order
data("incubA")

## the strings in the structure
st <- strings(incubA$IM)

## Get the partial order
partial.order(st)
```

perm

Array Permutation

Description

Function to permutate a given array of relation.

Usage

perm(x, clu, rev, lbs, sort)
Arguments

- **x**: a matrix or an array to be permuted
- **clu**: the cluster for the permutation
- **rev**: (optional and logical) whether the order in clu should be reverted.
- **lbs**: (optional) the labels after the permutation
- **sort**: (optional and logical) permute the array by sorting dimnames?

Details

This function serves to permute an array representing relations according to a vector for the clustering membership. By activating the **sort** argument to TRUE, all other arguments will be ignored.

Value

A permuted matrix or array

Author(s)

Antonio Rivero Ostoic

See Also

cph, partial.order

Examples

```r
## scan the multiplication table data
s <- matrix(data=c(1, 1, 1, 3, 3, 3, 3, 3, 3), nrow=3, ncol=3, byrow=TRUE)

## the permutation as an endomorphism
perm(s, clu = c(1,2,3))
perm(s, sort = TRUE)
```

pfvn

*Pathfinder valued network and triangle inequality*

Description

A function to establish the skeleton of a valued network with the pathfinder algorithm and triangle inequality

Usage

`pfvn(x, r, q)`
Arguments

- \( x \) network data, typically valued
- \( r \) a distance function parameter
- \( q \) parameter with the minimum distance between actors in the proximity matrix

Details

The Pathfinder structure is for undirected networks, whereas for directed network structures the triangle inequality principle is applied.

Value

- \( \max \) max value of the network with the Frobenius norm
- \( r \) parameter \( r \)
- \( q \) parameter \( q \)
- \( Q \) salient structure of \( x \)

Note

A note when triangle inequality is used

Author(s)

Antonio Rivero Ostoic

References


See Also

- `multigraph`

Examples

```r
# create valued network data
arr <- round( array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2)) ) * 10L

# pathfinder valued network of 'arr'
pfvn(arr)
```
pi.rels

\textbf{\pi-Relations}

\textbf{Description}

A function to establish the $\pi$-relations of a partially ordered structure coming from a 'Pacnet' class.

\textbf{Usage}

\texttt{pi.rels(x, po.incl, vc, po)}

\textbf{Arguments}

\begin{itemize}
\item \texttt{x} \hspace{1cm} an object of a 'Pacnet' class
\item \texttt{po.incl} \hspace{1cm} (optional and logical) should the partial order be included in the outcome?
\item \texttt{vc} \hspace{1cm} (optional) vector of the induced inclusions to be computed
\item \texttt{po} \hspace{1cm} (optional) the partial order structure
\end{itemize}

\textbf{Details}

This function processes the outcome of the Pacnet report by adding induced inclusions to partial order, the minimal element of the lattice of congruence relations. Such type of structure serves for the decomposition of a partially ordered semigroup structure.

\textbf{Value}

An object of the 'Pi.rels' class

\begin{itemize}
\item \texttt{pi} \hspace{1cm} the $\pi$-relations, eventually with the partial order
\item \texttt{mca} \hspace{1cm} the meet-complements of atoms
\end{itemize}

\textbf{Author(s)}

Antonio Rivero Ostoic

\textbf{References}


\textbf{See Also}

\texttt{pacnet, decomp}
Preview of the Semigroup Construction

Description

A function to preview the partial right multiplication table of the semigroup to assess the size of the complete semigroup.

Usage

`prev(x)`

Arguments

- `x`: an array; usually with three dimensions of stacked matrices where the multiple relations are placed.

Details

When the input data is large, i.e. having a dozen or more elements and/or more than five dimensions, it is recommended to perform this function before the semigroup construction in order to get the partial right multiplication table.

That is because the amount of undefined data in such table gives an idea of how much time may take to get the complete semigroup. However the performance depends mainly on whether the generator matrices are sparse and/or have a relative large number of elements for a semigroup construction of course.

Value

- `"2stpT"`: a partial right multiplication table at two-step.
- `"PcU2stpT"`: the proportion of undefined elements at two-step.
- `ordr`: the dimension of the right multiplication table so far.

Note

The warning message is given only if the percentage of undefined elements and the dimension of the input data are relative high. The semigroup construction can however still take long time without such message; cf. ‘Details’ for this.

Author(s)

Antonio Rivero Ostoic

See Also

`semigroup, edgeT`. 
**Examples**

```r
## Create the data: 2 binary relations among 3 elements
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2))>.5, 1 ) )
## preview it
prev(arr)
```

---

**rbox**

*Construct the Relation-Box*

---

**Description**

Function to construct the Relation-Box of a multiple network

**Usage**

```r
rbox(w, transp = FALSE, smpl = FALSE, k = 3, tlbs)
```

**Arguments**

- `w`: an array with three dimensions of stacked matrices of generating relations.
- `transp`: (logical) whether or not the transpose of each matrix in `w` should be included.
- `smpl`: (logical) whether to simplify or not the strings of relations
- `k`: length of the Relation-Box in `z`
- `tlbs`: (optional) a vector with the labels for the transpose relations.

**Details**

If `transp = TRUE` the labels of the transpose are toggle case of the labels of the original matrices, and in such case it is advised to simplify the strings of relations. In order to prevent a transposed structure for a certain array of `w`, use `NA` in the vector the transpose labels `tlbs` corresponding to the respective matrix.

**Value**

An object of the ‘Rel.Box’ class.

- `w`: the primitive relations in the Relation-Box
- `W`: the structure of the Relation-Box
- `lbs`: the labels in the relational system
- `Note`: (optional) Notes indicating the particularities in the input
- `Orels`: the original labels of the relations
- `Srels`: (optional) the simplified labels of the relations
- `Trels`: (optional) the labels of the transposed relations
- `k`: the maximal length of the word
- `z`: the length of the Relation-Box in the `z` dimension
Note
Values of k until 9 is supported. With many types of relations, and when the order of the multiple network is high, turning k to more than three may take a long time of computation.

Author(s)
Antonio Rivero Ostoic

References

See Also
cph, semigroup, hierar

Examples
```r
## load the data
data("incubA")

## The relation box of the image matrices
## Not run:
rbox(incubA$IM)
## End(**Not run**)  
```

Description
A function to read files with the Ucinet dl format.

Usage
`read.dl(file)`

Arguments
- `file` character vector containing a file name or path of the data representing the network

Details
Files dl serve to represent multiple network structures, and it is one of the formats used in Netdraw, which is a component of the Ucinet program. Besides multiple networks, the function can read two-mode structures as well.
Value

A data frame for two-mode networks, or an array representing the multiple networks with one set of actors.

Note

The 'EDGELIST' option in DL is not yet supported for reading.

Author(s)

Antonio Rivero Ostoic

References


See Also

write.dl, read.srt, read.gml

Description

A function to read files with the gml format.

Usage

read.gml(file, as = c("srt", "array"), directed = TRUE, coords = FALSE)

Arguments

file character vector containing a file name or path
as should the data be given as a srt or with an array format?
directed (logical) whether the graph is directed or undirected.
coords (logical) whether the coordinates in the gml file should be included.

Details

The gml format, an acronym for graph modelling language, provides capabilities to represent multiple networks and add arguments to both the nodes and the edges for visualization purposes.

For the multiplexity in the ties, the gml file distinguishes “graphics” arguments inside “edge”. Both “style” and “fill” are supported here and the former has priority over the latter in case the two are given; otherwise when these arguments are absent. The function separates up to a couple of relational levels when several pairwise ties are specified.
Value

Depending the option chosen, the output is either a data frame or an array representing the multigraph. If the coordinates are chosen then these are part of the object structure, but they are not visible.

Note

If the coordinates are chosen, node attributes can also be retrieved.

Author(s)

Antonio Rivero Ostoic

References


See Also

write.gml, read.srt, read.dl

---

read.srt Read srt Files

Description

A function to read files with send, receive, and ties format for a multivariate network with the possibility to transform it into a three dimensional array.

Usage

read.srt(file, header = TRUE, sep = "\t", toarray = TRUE, dichot = FALSE, attr = FALSE, rownames = FALSE, add = NULL)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>file</td>
<td>path to the file</td>
</tr>
<tr>
<td>header</td>
<td>(logical) does the file has a header?</td>
</tr>
<tr>
<td>sep</td>
<td>the separator among the columns (default is horizontal tab)</td>
</tr>
<tr>
<td>toarray</td>
<td>(logical) should the data frame be transformed to arrays?</td>
</tr>
<tr>
<td>dichot</td>
<td>(logical) should the data be dichotomized?</td>
</tr>
<tr>
<td>attr</td>
<td>(logical) whether or not the file corresponds to attribute-based data</td>
</tr>
<tr>
<td>rownames</td>
<td>(logical) are rownames the labels of the nodes?</td>
</tr>
<tr>
<td>add</td>
<td>(optional) isolates to be added to the network</td>
</tr>
</tbody>
</table>
Details

srt stands for send, receive, and ties, and it is a data frame with at least 3 columns for the sender, receiver, and the ties, one column for each type of relation. However, the attr option correspond to a actor and self-ties data frame file with the option to transform it into a diagonal matrix. When toarray is set to FALSE, options attr and rownames allow placing the first column of the data frame as the name of the table, which is the format of two-mode data, and compute for instance Galois transformations among the partite sets. If more than one isolate is added, then the data must be included as a vector.

It is also possible to treat the input data as data frame object and manipulate it via e.g. the subset function with the toarray option.

Value

By default an array; usually with three dimensions of stacked matrices where the multiple relations are placed. If toarray = FALSE, then the data frame is given.

Note

The function supports valued networks as well.

Author(s)

Antonio Rivero Ostoic

See Also

write.srt, read.gml, read.dl, galois

reduc  Reduce a matrix or array

Description

Function to reduce a matrix or array with a given clustering vector

Usage

reduc(x, clu, lbs = NULL, slbs = NULL, valued, row, col)

Arguments

x  a matrix or a three-dimensional array to be reduced
clu  a vector with the class membership
lbs  (optional) the labels to be used in the reduction
slbs  (optional) the string labels to be used in the reduction
valued  (logical) whether the reduction should preserve valued data?
row  (optional) the reduction by rows
col  (optional) the reduction by columns
Details

Given a partition, this function serves to reduce either a matrix representing e.g. a partial order structure. However the reduction is also generalized a three-dimensional arrays representing multiple relations.

Value

The reduced matrix or a reduced three-dimensional array of the input data according to the clustering information.

Note

Use `decomp` for the reduction of a semigroup object.

Author(s)

Antonio Rivero Ostoic

See Also

cngr, rbox, decomp

Examples

```r
## scan the multiplication table data
s <- matrix(data=c(1, 1, 1, 3, 3, 3, 3, 3, 3), nrow=3, ncol=3, byrow=TRUE)

## Reduce the multiplication table
reduc(s, clu=c(1,2,2))
```

rel.sys

Relational System

Description

Create the Relation System of a multiple network.

Usage

```r
rel.sys(x, type = c("tolist", "toarray"), bonds = c("entire", "strong", "weak", "asym", "recp", "txch", "tent", "mixd", "full"), sel = NULL, loops = FALSE, att = NULL, sep)
```
Arguments

- **x**: an array; usually with three dimensions of stacked matrices where the multiple relations are placed.
- **type**: if the transformation is from (array of) matrices into lists of pairwise relations or vice versa
- **bonds**: the type of bonds to be used in the creation of the relational system (default the 'entire' network)
- **sel**: (optional) the set of actors to be selected. For "toarray" att and noatt also supported (see details)
- **loops**: (logical) whether or not the loops should be considered in the relational system
- **att**: the arrays in x corresponding to attributes
- **sep**: (optional) the pair separator for the pairwise relations

Details

When the type of bonds chosen is entire then the nodes with ties are considered in the relational system without isolated nodes. strong bonds are relational bundles with a mutual character, whereas weak bonds are those pattern exclusively without mutual character.

When selecting from a list with actor attributes, it is also possible to select the network members having or not the attribute that is specified in the Attrs output. Use att or noatt for the two options.

Value

An object of 'Rel.System' class for the type = "tolist" (default) option. The items are:

- **ord**: order of the network relational system
- **nodes**: the nodes in the relational system
- **sel**: the selected set of actors
- **sys.ord**: the order of the relational system with the chosen bond type
- **incl**: the nodes included the relational system with the chosen bond type
- **excl**: the nodes excluded the relational system with the chosen bond type
- **bond.type**: the type of bonds used in the relational system creation
- **size**: number of ties in the relational system
- **Note**: (optional) note
- **sep**: the pairwise separator of the relational system
- **Ties**: the ties in the relational system
- **Attrs.ord**: if att is not NULL, the number of nodes with the chosen attribute(s)
- **Attrs**: if att is not NULL, the actors with the chosen attribute(s)

For type = "toarray" the output is a dichotomous 2D or 3D array recording the relations among the actors in the network.
Author(s)

Antonio Rivero Ostoic

References


See Also

expos, bundles, neighb

Examples

```r
## Create the data: two binary relations among three elements
arr <- round( replace( array( runif(18), c(3,3,2) ), array( runif(18), c(3,3,2) ) > .9, 3 ) )

## Determine the system of strong bonds
rel.sys(arr, bonds = "strong")

## the first array is for attributes
rel.sys(arr, att = 1)

## select the first node
rel.sys(arr, sel = 1)
```

---

**rm.isol**

*Remove Isolates*

**Description**

Function to remove isolate nodes in simple and multiple networks.

**Usage**

```r
rm.isol(x, diag, diag.incl)
```

**Arguments**

- **x**: a matrix or array representing a network
- **diag**: (optional and logical) if arrays, should the diagonals be included in the computation?
- **diag.incl**: (optional and logical) if arrays, should the diagonals be included in the output?
Details

Isolated nodes do not have any edges in the network, and in a multivariate system, there is no edges adjacent to these kinds of nodes at any level.

Value

The matrix or array representing a multiple network without the isolated actors.

Author(s)

Antonio Rivero Ostoic

See Also

`read.srt`, `zbind`

Examples

```r
## Create the data: two binary relations among three elements
arr <- round(replace(array(runif(18), c(3, 3, 2)), array(runif(18), c(3, 3, 2)) > .5, 3))

## Remove isolates (if exist)
rm.isol(arr)
```

Description

Function to create the complete semigroup of multiple relations, where the multiplication table can be specified with either a numerical or a symbolic form.

Usage

```r
semigroup(x, type = c("numerical", "symbolic"), cmps, smpl, valued)
```

Arguments

- **x**: an array; usually with three dimensions of stacked matrices where the multiple relations are placed.
- **type**: whether the semigroup should be returned with a numerical (default) or in a symbolic form?
- **cmps**: (optional and logical) a logical to indicate whether the composite matrices should be also given in the output.
- **smpl**: (logical and logical) whether to simplify or not the strings of relations.
- **valued**: (logical) whether the semigroup should be with a valued format
Details

A multiple relation can be defined by square matrices of 0’s and 1’s indicating the presence and absence of ties among a set of actors. If there is more than one relation type, the matrices must preserve the label ordering of its elements and stacked into an object array in order to be effectively applied to this function.

The semigroup, which is an algebraic structure having a set with an associative operation on it, is calculated considering binary matrices only. This means that if the provided matrices are valued, the function will dichotomize the input data automatically; values higher or equal to a unit are converted to one, otherwise they are set to zero. If you are not happy with that, you can go to \texttt{dichot} and specify your own cutoff value for the dichotomization.

Semigroup structures for valued relations apply the max min operation in the composition of generators and strings.

Value

An object of ‘\texttt{Semigroup}’ class. The items included are:

\begin{itemize}
  \item \texttt{gens} \hspace{1cm} an array with the generator relations
  \item \texttt{cmps} \hspace{1cm} an array with the unique compound relations
  \item \texttt{ord} \hspace{1cm} a number with the dimension of the semigroup
  \item \texttt{st} \hspace{1cm} the strings, i.e. a vector of the unique relations
  \item \texttt{S} \hspace{1cm} the semigroup of relations (see below)
\end{itemize}

If the specified type is ‘\texttt{numerical}’, then a matrix of semigroup values is given, otherwise the values is returned as a data frame with the strings of the semigroup.

Warning

For medium size or bigger sets (having e.g. more the 4 relation types), the semigroup construction could take a long time.

Note

It is recommendable to perform the function \texttt{prev} before attempting to construct the semigroup, unless the input data has few dimensions.

Author(s)

Antonio Rivero Ostoic

References


semiring

See Also

prev.strings, edgeT, wordT, dichot, cngr.

Examples

```r
## Create the data: 2 binary relations among 3 elements
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2))>.5, 1 ) )

## optional: put labels
dimnames(arr)[[3]] <- list("n", "m")

## look at the semigroup
semigroup(arr)
```

Description

A function to construct semiring structures for the analysis of structural balance theory.

Usage

```r
semiring(x, type = c("balance", "cluster"), symclos = TRUE, transclos = TRUE, k = 2, lbs)
```

Arguments

- `x`: an object of a ‘Signed’ class
- `type`: balance or cluster semiring?
- `symclos`: (logical) apply symmetric closure?
- `transclos`: (logical) apply transitive closure?
- `k`: length of the cycle or the semicycle
- `lbs`: (optional) labels for the semiring output

Details

Semiring structures are based on signed networks, and this function provides the capabilities to handle either the balance semiring or the cluster semiring within the structural balance theory.

A semiring combines two different kinds of operations with a single underlying set, and it can be seen as an abstract semigroup with identity under multiplication and a commutative monoid under addition. Semirings are useful to determine whether a given signed network is balanced or clusterable. The symmetric closure evaluates this by looking at semicycles in the system; otherwise the evaluation is through closed paths.
Value

An object of ‘Semiring’ class. The items included are:

- `val` the valences in the semiring
- `s` the original semiring structure
- `Q` the resulted semiring structure
- `k` the number of cycles or semicycles

Note

Disabling transitive closure should be made with good substantial reasons.

Author(s)

Antonio Rivero Ostoic

References


See Also

`signed`, `as.signed`

Examples

```r
## Create the data: two sets with a pair of binary relations
## among three elements
arr <- round( replace( array( runif(18), c(3 ,3, 2) ), array( runif(18), c(3, 3, 2) ) > .5, 3 ) )

## Make the signed matrix with two types of relations
gs <- signed(arr)

## Establish the semiring structure
semiring(gs)
```
signed

Signed Network

Description

Construct the signed network of a system of contrasting relations

Usage

signed(P, N = NULL, lbs)

Arguments

P array with the positive ties and possible with negative ties (see Details)
N (optional) array with the negative ties
lbs (optional) labels for the signed matrix

Details

This function coerce an array(s) to become a ‘Signed’ object. Positive ties are always in the first argument, and in case that this array has three dimensions, the second dimension is considered as the negative ties, provided that N still NULL. If ambivalent ties are present in the structure then the signed matrix represent positive, negative, ambivalent, and null ties as p, n, a, and o respectively; otherwise the values are 1, -1, and 0.

Value

An object of ‘Signed’ class with items:

val the valences in the signed matrix
s the signed matrix

Note

A warning message is shown when the N argument has more than two dimensions.

Author(s)

Antonio Rivero Ostoic

References


See Also

semiring, as.signed
Examples

```r
## Load the data
data("incubA")

## Make the signed matrix with two types of relations
signed(incubA$IM)
```

---

strings  

**Strings of Relations**

Description

Function to get the labels of the unique relations of the semigroup; that is the generators and compound relations that are the elements of the complete semigroup.

Usage

```r
strings(x, equat = FALSE, k = 2, smpl, valued)
```

Arguments

- `x`: an array; usually with three dimensions of stacked matrices where the multiple relations are placed.
- `equat`: (logical) should the equations be included in the output?
- `k`: length of the strings in the equations
- `smpl`: (optional and logical) whether to simplify or not the string relations
- `valued`: (logical) whether the strings are with a valued format

Details

The strings are the unique relations, which constitutes the elements of the complete semigroup. These are both the generators and the compound relations after applying the Axiom of Quality, which means that even some generators can be disregarded.

This function is especially useful to construct the partial order of relations, and to establish the set of equations in the relational structure.

Value

An object of ‘Strings’ class.

```r
wt the generators and compound relations
ord the order of the structure
st the labels of the unique relations
equat the equations among strings of relations
```
Note

The maximum length of the strings in the equations is currently 4.

Author(s)

Antonio Rivero Ostoic

References


See Also

partial.order, semigroup.

Examples

```r
## Create the data: 2 binary relations among 3 elements
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2))>.5, 1 ) )

## get the strings
strings(arr)
```

```
summaryBundles(x, file = NULL, latex = FALSE, byties)
```

### Description

Pretty printing of the bundle class patterns results.

### Usage

`summaryBundles(x, file = NULL, latex = FALSE, byties)`

### Arguments

- `x`  
  an object of the `Rel.Bundles` class
- `file`  
  (optional) the path where the output file is to be placed
- `latex`  
  (logical) whether the output should be in latex format or not
- `byties`  
  (optional and logical) expand tie patterns and collapse tie labels?
**Details**

This function prints the bundle census patterns existing in the network with an option to export such information in a friendly format. The dyadic bundle patterns are provide by the function `bundles`; however the outcome of this function provides a list of pair lists for each bundle with the involved types of relations and nodes in the network. This form for presentation, although is convenient for further computation, it is not always easy to read for a human eye. The pair separator used to print the bundle occurrences is taken from the output of the `bundles` function.

If `latex` is set to `TRUE`, then the path file is activated to obtain a `tex` file with the different bundle class patterns. Finally, the optional argument `byties` provides a more precise information of the patterned ties disregarding the relational content.

**Value**

The distinct bundle class patterns with a user friendly format.

**Note**

If a file with the same name already exists in the pointed directory, then this file will be overwritten.

**Author(s)**

Antonio Rivero Ostoic

**References**


**See Also**

`bundles`, `bundle.census`

**Examples**

```r
## Create the data: 2 binary relations among 3 elements
arr <- round( replace( array( runif(18), c(3, 3, 2) ), array( runif(18), c(3, 3, 2) ) > .8, 3 ) )

## Establish the different bundles
bd <- bundles(arr)

## Print the different relational bundles
summaryBundles(bd)
```
Transform Data from/to Matrix/List Formats

Description
Function to transform data from/to matrix/list formats representing a network.

Usage
```
transf(x, type = c("toarray", "tolist", "toarray2"), lbs = NULL, lb2lb, sep, ord, sort, sym, add, adc)
```

Arguments
- **x**: an array or a list of pair relations
- **type**: whether the transformation is from a list of pair relations to an array format, or from a matrix to a list of pair relations, or else from a list of pair relations to a square array
- **lbs**: (optional) the labels in the transformation (disabled for ‘toarray’)
- **lb2lb**: (optional and logical) whether the transformation is label-to-label. Default TRUE for "toarray" and FALSE for "tolist"
- **sep**: (optional) the pair separator for the pairwise relations
- **ord**: (optional) the order of the resulted structure (‘toarray’ option, otherwise ignored)
- **sort**: (optional and logical) sort the arrays in the output?
- **sym**: (optional and logical) symmetrize the arrays? (‘toarray’ option, otherwise ignored)
- **add**: (optional) add elements in the array’s ‘domain’
- **adc**: (optional) add elements in the array’s ‘codomain’

Details
- ‘tolist’ is the option to transform a matrix or an array to a list of pair elements. In case that the lb2lb is enabled in this type of transformation, then lbs must be provided, whereas the pair separator is optional. On the other hand, ‘toarray’ will produce a matrix from a list of pair elements, and in this case is advisable to specify the order of the structure. Three-dimensional structures are now supported.
- Data frames are also accepted for the ‘tolist’ option, but in case that such information is given as a list of pair relations, the output will be a square matrix.

Value
Depending on the input data, the result is either a list of pair relations or a matrix of relations.
Note

For high dimensional arrays, the `rel.sys` function provides additional information other than the list of pair relations of the entire structure.

Author(s)

Antonio Rivero Ostoic

See Also

`read.srt`, `bundles`, `reduc`, `rel.sys`

Examples

```r
## scan the multiplication table data
s <- matrix(data=c(1, 1, 1, 3, 3, 3, 3, 3, 3), nrow=3, ncol=3, byrow=TRUE)

## transform the matrix to a list format
transf(s, lb2lb = TRUE, lbs = c('n', 'm', 'ñ'))
```

---

wordT

*The Word Table of Relations*

Description

The Word Table of multiple relations.

Usage

```r
wordT(x)
```

Arguments

- `x` an array; usually with three dimensions of stacked matrices where the multiple relations are placed.

Details

The Word Table is a consequence of the Edge Table and the function gives a list of indexed elements in the complete semigroup.

In terms of the Cayley graph of the semigroup (cf. CRANpkgccgraph), the collection of unique relations (both compound and generators) are represented by nodes. On the other hand, the generators are edges that record the result of post-multiplying the compound relations by the generators.
write.dat

Value
An object of the ‘WordTable’ class
gens the generator relations
WT the Word Table where “n” stands for “node” and “g” stands for “generator”
The generators do not have values in neither the “node” nor the “generator” of the Word table since they are not product of any other element in the semigroup (cf. details for the rest of the values).

Note
The labels for the elements can be retrieved by the strings function.

Author(s)
Antonio Rivero Ostoic

References

See Also
dgeT, semigroup.

Examples
```
## Create the data: 2 binary relations among 3 elements
arr <- round( replace( array(runif(18), c(3,3,2)), array(runif(18), c(3,3,2))>.5, 1 ) )

## get the word table
wordT(arr)
```

write.dat Write dat Files

Description
A function to write dat files.

Usage
write.dat(x, path)
Arguments

\begin{itemize}
\item \textbf{x} \hspace{1cm} an object representing the multiple network structure
\item \textbf{path} \hspace{1cm} the path file for the output
\end{itemize}

Details

‘dat’ files are the format used in the Pacnet program. In case that the input data represents a multiple network then a separate file will be produced, each one representing a single type of relationship in the system. The name of the output files depends on the object title.

Value

File(s) with adjacency matrices with a .dat format

Note

In case that the directory in the path for the output does not exist then it will be created automatically.

Author(s)

Antonio Rivero Ostoic

References

StOCNET An open software system for the advanced statistical analysis of social networks.
http://www.gmw.rug.nl/~stocnet/

See Also

pacnet, write.gml, write.dl

write.dl \hspace{1cm} \textit{Write dl Files}

Description

A function to write dl files representing multiple networks.

Usage

\begin{verbatim}
write.dl(x, file = NULL, type = c("nodelist", "fullmat"))
\end{verbatim}

Arguments

\begin{itemize}
\item \textbf{x} \hspace{1cm} an object representing the multiple network
\item \textbf{file} \hspace{1cm} path to the file
\item \textbf{type} \hspace{1cm} whether to write the data as a nodelist or as a fullmat format
\end{itemize}
Details
dl files serve to represent multiple networks, and it is one of the formats used in Netdraw, which is a component of the Ucinet program.

Value
A file with the data with a .dl format

Author(s)
Antonio Rivero Ostoic

References

See Also
read.dl, write.gml, write.srt, write.dat

write.gml

Write gml Files

Description
A function to write files with a gml format.

Usage
write.gml(x, file = NULL)

Arguments
x an object representing the multiple network
file path to the file

Details
The gml format, an acronym for graph modelling language, provides capabilities to represent multiple networks and add arguments to both the nodes and the edges for visualization purposes.

Value
A file with the data with a graph modelling language format.
Note

In case that the file already exists in the pointed directory, then the file will be overwritten.

Author(s)

Antonio Rivero Ostoic

References


See Also

read.gml, write.dl, write.dat

write.srt

Write srt Files

Description

A function to write srt files

Usage

write.srt(x, file = NULL, sep = "\t", header = TRUE)

Arguments

x

an object representing the multiple network

file

path to the file

sep

the separator used between the columns

header

(logical) whether the header should be included in the file

Details

srt stands for send, receive, and ties, and it is a data frame with at least 3 columns for the sender, receiver, and the ties, one column for each type of relation.

Value

A file with the data with a .srt format

Author(s)

Antonio Rivero Ostoic

See Also

read.srt, write.dl
Description
Combine multidimensional arrays.

Usage
zbind(...)

Arguments
... One or more arrays with two or three dimensions

Details
This function is for stacking two-dimensional arrays into a single three-dimensional object to represent a multivariate system structure. Both square and rectangular arrays are supported provided that the dimensions in the input are equal. The dimnames in the output correspond to the first array in the input, and a Warning message is given when these are NULL.

Value
Usually a three dimensional array

Note
Data frames should be transformed into arrays

Author(s)
Antonio Rivero Ostoic

See Also
mnplx, dichot, strings

Examples
## Create the data: two sets with a pair of binary relations
## among three elements
arr1 <- round( replace( array( runif(18), c(3 ,3, 2) ), array( runif(18), c(3, 3, 2) ) > .5, 3 ) )

arr2 <- round( replace( array( runif(18), c(3,3, 2) ), array( runif(18), c(3, 3, 2) ) > .5, 3 ) )

## bind the data sets
zbind(arr1, arr2)
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