Package ‘rgraph6’

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Title Representing Graphs as 'graph6', 'digraph6' or 'sparse6' Strings

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Description Encode network data as strings of printable ASCII characters. Implemented functions include encoding and decoding adjacency matrices, edgelists, igraph, and network objects to/from formats 'graph6', 'sparse6', and 'digraph6'. The formats and methods are described in McKay, B.D. and Piperno, A (2014) <doi:10.1016/j.jsc.2013.09.003>.

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RoxygenNote 7.2.1

Encoding UTF-8

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URL https://mbojan.github.io/rgraph6/

BugReports https://github.com/mbojan/rgraph6/issues

VignetteBuilder knitr

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rgraph6-package

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rgraph6-package  rgraph6: Representing Graphs as 'graph6', 'digraph6' or 'sparse6'
Strings

Description

Encode network data as strings of printable ASCII characters. Implemented functions include encoding and decoding adjacency matrices, edgelists, igraph, and network objects to/from formats 'graph6', 'sparse6', and 'digraph6'. The formats and methods are described in McKay, B.D. and Piperno, A (2014) doi:10.1016/j.jsc.2013.09.003.

Details

Formats 'graph6', 'sparse6' and 'digraph6' represent graphs as strings of printable ASCII characters. The formats are due to Brendan McKay who implemented them in his program Nauty (McKay 1978, 1980, 2003, McKay & Piperno 2014), and are described in detail here. Package rgraph6 is a native R implementation of these formats.

The main functions are as_graph6(), as_digraph6(), as_sparse6() for encoding network data and igraph_from_text() and network_from_text() for decoding. There are also other low-level functions to decode directly from digraph6, graph6, and sparse6.

Citation

When using this package please cite it by referring to the following publications: McKay B, Piperno A (2014). "Practical graph isomorphism, II." Journal of Symbolic Computation, 60, 94-112.

adjacency_from_text

Call citation(package="rgraph6") for more details and the BibTeX entry.

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References

McKay, B. D., & Piperno, A. (2013). Nauty and Traces user’s guide (Version 2.5). Computer Science Department, Australian National University, Canberra, Australia.

See Also

Useful links:
- https://mbojan.github.io/rgraph6/
- Report bugs at https://github.com/mbojan/rgraph6/issues

adjacency_from_text Create adjacency matrices from 'graph6', 'sparse6', or 'digraph6' symbols

Description

Create adjacency matrices from 'graph6', 'sparse6', or 'digraph6' symbols

Usage

adjacency_from_text(object, ...)

Arguments

object character vector of 'graph6', 'sparse6', or 'digraph6' symbols
... other arguments, currently ignored
Details

If object contains 'sparse6' symbols, which are in fact encoded edgelists, the function will return corresponding adjacency matrices creating temporary igraph objects internally.

Value

A list of adjacency matrices.

Examples

```r
# Graph6 symbols
sampleg6
adjacency_from_text(sampleg6)

# Sparse6 symbols
s6 <- c(":DgXI@G~", ":DgWCgCb")
adjacency_from_text(s6)

# Digraph6 symbol
d6 <- "&N????C??D?_G??C????_?C_??????C??Q@O?G?"
adjacency_from_text(d6)
```

Description

Generic function encoding directed networks as 'digraph6' symbol(s). See below for available methods.

Usage

```r
as_digraph6(object)

## S3 method for class 'matrix'
as_digraph6(object)

## S3 method for class 'igraph'
as_digraph6(object)

## S3 method for class 'network'
as_digraph6(object)

## S3 method for class 'list'
as_digraph6(object)

## Default S3 method:
as_digraph6(object)
```
as_digraph6

Arguments
object a matrix, an igraph object or a network object or a list thereof. See Methods section below.

Details
The 'digraph6' format is designed for directed graphs. Error is thrown in case it is given an undirected network.

Value
A character vector of 'digraph6' symbols.

Methods (by class)
• as_digraph6(matrix): Expects object to be a square matrix which is interpreted as an adjacency matrix of a directed graph.
• as_digraph6(igraph): Igraph object needs to be a directed graph. Requires igraph package.
• as_digraph6(network): Network object needs to be directed network. Requires network package.
• as_digraph6(list): If object is a list the function is applied to each element. Consequently, it can be a list with a mixture of supported objects classes (adjacency matrices, igraph, or network objects).
• as_digraph6(default): Throws an error about the unhandled class.

Examples
# From adjacency matrix -----------------------------------------------
am <- matrix(c( 0,1,0, 0,0,1, 1,0,0), byrow=TRUE, ncol=3, nrow=3) as_digraph6(am)

# From igraph objects -------------------------------------------------
if(requireNamespace("igraph", quietly=TRUE)) {
g <- igraph::graph_from_adjacency_matrix(am)
as_digraph6(g)
}

# From network objects -------------------------------------------------
if(requireNamespace("network", quietly=TRUE)) {
net <- network::network(am)
as_digraph6(net)
}
as_graph6

Encode network data as 'graph6' symbols

Description

Generic function encoding undirected networks as 'graph6' symbol(s). See below for available methods.

Usage

as_graph6(object)

## S3 method for class 'matrix'
as_graph6(object)

## S3 method for class 'igraph'
as_graph6(object)

## S3 method for class 'network'
as_graph6(object)

## S3 method for class 'list'
as_graph6(object)

## Default S3 method:
as_graph6(object)

Arguments

object a matrix, an igraph object or a network object or a list thereof. See Methods section below.

Details

The 'graph6' format is designed for undirected graphs. Error is thrown in case it is given a directed graph.

Value

A character vector of 'graph6' symbols.

Methods (by class)

- as_graph6(matrix): Expects object to be a square matrix which is interpreted as an adjacency matrix of an undirected graph. The function reads only the upper triangle of the matrix and there is no test whether the matrix is symmetric.
as_graph6(igraph): Igraph object needs to be an undirected graph. Requires igraph package.

as_graph6(network): Network object needs to be a directed network. Requires network package.

as_graph6(list): If object is a list the function is applied to each element. Consequently, it can be a list with a mixture of supported objects classes (adjacency matrices, igraph, or network objects).

as_graph6(default): The default method throws an error about an unhandled class.

Examples

# From adjacency matrix -----------------------------------------------
am <- matrix(c(0,1,1,1,0,0,1,0,0), byrow=TRUE, ncol=3)
as_graph6(am)

# From igraph objects -----------------------------------------------
if(requireNamespace("igraph", quietly=TRUE)) {
  g <- igraph::graph_from_adjacency_matrix(am, mode = "undirected")
as_graph6(g)
}

# From network objects -----------------------------------------------
if(requireNamespace("network", quietly=TRUE)) {
  net <- network::network(am, directed=FALSE)
as_graph6(net)
}

as_sparse6

Encode network data as sparse6 symbols

Description

Generic function encoding network data as 'sparse6' symbol(s). See below for available methods.

Usage

as_sparse6(object, ...)

## S3 method for class 'matrix'
as_sparse6(object, n = max(object, 0), ...)

## S3 method for class 'igraph'
as_sparse6(object, ...)
## S3 method for class 'network'
\texttt{as\_sparse6}(object, ...)

## S3 method for class 'list'
\texttt{as\_sparse6}(object, ...)

## Default S3 method:
\texttt{as\_sparse6}(object, ...)

### Arguments

- **object**: an edgelist, igraph, or network object or a list thereof. See Methods section below.
- **...**: other arguments passed to/from other methods
- **n**: number of vertices in the graph

### Value

A character vector of 'sparse6' symbols.

### Methods (by class)

- **as\_sparse6(matrix)**: Expects \texttt{object} to be a two-column matrix of integers which is interpreted as an edgelist of an undirected graph. By default the network size is inferred to be the maximal element of \texttt{object}. This can be overridden by providing the network size via the \texttt{n} argument, the results will not be identical though (see the Examples).
- **as\_sparse6(igraph)**: Igraph object needs to be an undirected graph. Requires \texttt{igraph} package.
- **as\_sparse6(network)**: Network object needs to be a directed network. Requires \texttt{network} package.
- **as\_sparse6(list)**: If \texttt{object} is a list the function is applied to each element. Consequently, it can be a list with a mixture of supported objects classes (edgelist matrices, igraph, or network objects).
- **as\_sparse6(default)**: The default method fails gracefully.

### See Also

The 'sparse6' format is designed for undirected graphs. Error is thrown in case it is given a directed graph.

### Examples

```r
# From edgelist matrix
elm <- matrix(c(
  1, 2,
  2, 3,
  3, 4
```
choose_format

`, ncol=2, byrow=TRUE)
  as_sparse6(elm) # 1--2, 2--3, 3--4
  as_sparse6(elm + 6) # 1, 2, 3, 4, 5, 6, 7--8, 8--9, 9--10
  as_sparse6(elm, n = 10) # 1--2, 2--3, 3--4, 5, 6, 7, 8, 9, 10

  # From igraph objects -----------------------------------------
  if(requireNamespace("igraph")) {
    g <- igraph::graph_from_edgelist(elm, directed=FALSE)
    as_sparse6(g)
  }

  # From network objects --------------------------------
  if(requireNamespace("network")) {
    net <- network::network(elm, directed=FALSE)
    as_graph6(net)
  }

choose_format  Choose most efficient format heuristically

Description

Given a graph suggest the most efficient format out of 'graph6', 'sparse6' or 'digraph6'.

Usage

choose_format(object, ...)

## Default S3 method:
choose_format(object, ...)

## S3 method for class 'list'
choose_format(object, ...)

Arguments

object  Igraph/network object or list thereof
...
other arguments, currently ignored

Details

If object is directed, the suggested format is 'digraph6'. If object is undirected the function suggests 'sparse6' if density is less than 0.15 and 'graph6' otherwise. This rule is approximate.

Value

Character value out of 'graph6', 'sparse6' or 'digraph6'. If object is a list, a vector of such values of the length equal to the length of object.
edgelist_from_text

Create edgelist matrices from 'graph6', 'sparse6', or 'digraph6' symbols

Description
Create edgelist matrices from 'graph6', 'sparse6', or 'digraph6' symbols

Usage
edgelist_from_text(object, ...)

Arguments
object character vector of 'graph6', 'sparse6', or 'digraph6' symbols
... other arguments, currently ignored

Details
If object contains 'graph6' or 'digraph6' symbols, which are in fact encoded adjacency matrices, the function will return corresponding edgelist matrices creating temporary igraph objects internally.

Value
A list of edgelist matrices.
Examples

# Graph6 symbols
sampleg6
edgelist_from_text(sampleg6)

# Sparse6 symbols
s6 <- c(":DgXI@G~", ":DgWCgCb")
edgelist_from_text(s6)

# Digraph6 symbol
d6 <- "&N????C??D?_G??C?????_C_??????C??Q@O?G?"
edgelist_from_text(d6)

from_digraph6 Parsing digraph6 symbols

Description

These functions take a vector of 'digraph6' symbols and return a list of other types of objects:

- adjacency_from_digraph6() creates adjacency matrices
- igraph_from_digraph6() creates 'igraph' objects. Requires package igraph to be installed.
- network_from_digraph6() creates 'network' objects. Requires package network to be installed.

Usage

adjacency_from_digraph6(d6)

igraph_from_digraph6(d6, ...)

network_from_digraph6(d6, ...)

Arguments

d6 character vector of 'digraph6' symbols
... other arguments, see Details.

Details

For igraph_from_digraph6() additional arguments are passed to igraph::graph_from_adjacency_matrix()
For network_from_digraph6() additional arguments are passed to network::as.network()
from_graph6

Value

The returned object is:

- for `adjacency_from_digraph6()`, a list of the same length as its input of square symmetric adjacency matrices.

- for `igraph_from_digraph6()`, a list of `igraph` objects

- for `network_from_digraph6()`, a list of `network` objects

See Also

`as_digraph6()` for encoding objects as 'digraph6' symbols.

Examples

```r
am <- matrix(rbinom(16, 1, 0.3), 4, 4)
d6 <- as_digraph6(am)

# To adjacency matrix -----------------------------------------------
adjacency_from_digraph6(d6)

# To igraph objects --------------------------------------------------
if(requireNamespace("igraph", quietly=TRUE)) {
  igraph_from_digraph6(d6)
}

# To network objects --------------------------------------------------
if(requireNamespace("network", quietly=TRUE)) {
  network_from_digraph6(d6)
}
```

from_graph6

Functions parsing 'graph6' symbols

Description

These functions take a vector of 'graph6' symbols and return a list of other types of objects:

- `adjacency_from_graph6()` creates adjacency matrices

- `igraph_from_graph6()` creates `igraph` objects. Requires package `igraph` to be installed.

- `network_from_graph6()` creates network objects. Requires package `network` to be installed.
from_graph6

Usage

adjacency_from_graph6(g6)
igraph_from_graph6(g6, ...)
network_from_graph6(g6, ...)

Arguments

g6 character vector of 'graph6' symbols

... other arguments, see Details.

Details

For igraph_from_graph6() additional arguments are passed to igraph::graph_from_adjacency_matrix()
For network_from_graph6() additional arguments are passed to network::as.network()

Value

The returned object is:

- for adjacency_from_graph6(), a list of the same length as its input of square symmetric adjacency matrices.
- for igraph_from_graph6(), a list of 'igraph' objects
- for network_from_graph6(), a list of network objects

See Also

as_graph6() for saving objects as 'graph6' symbols.

Examples

A <- matrix(c(0,1,0,1,
              1,0,1,0,
              0,1,0,1,
              1,0,1,0), 4, 4, byrow = TRUE)
g6 <- as_graph6(A)

# To adjacency matrix -----------------------------------------------
adjacency_from_graph6(g6)

# To igraph objects --------------------------------------------------
if(requireNamespace("igraph", quietly=TRUE)) {
  igraph_from_graph6(g6)
}

# To network objects --------------------------------------------------
if(requireNamespace("network", quietly=TRUE)) {
network_from_graph6(g6)
}

from_sparse6 Parsing 'sparse6' symbols

Description
These functions take a character vector of 'sparse6' symbols and return a list of other types of objects:

- edgelist_from_sparse6() creates edgelist matrices
- igraph_from_sparse6() creates 'igraph' objects. Requires package igraph to be installed.
- network_from_sparse6() creates 'network' objects. Requires package network to be installed.

Usage
edgelist_from_sparse6(s6)
igraph_from_sparse6(s6)
network_from_sparse6(s6)

Arguments
s6 character vector of 'sparse6' symbols

Value
The returned object is:

- for edgelist_from_sparse6(), a list of the same length as its input of two-column edgelist matrices. The matrix has a gorder attribute storing the number of vertices in the graph.
- for igraph_from_sparse6(), a list of 'igraph' objects
- for network_from_sparse6(), a list of 'network' objects

See Also
as_sparse6() for encoding network data objects as 'sparse6' symbols.
Examples

elm <- structure(c(1, 1, 2, 2, 4, 4, 5, 6, 9, 10, 7, 8, 4, 8, 6, 8,
8, 5, 4, 6), .Dim = c(10L, 2L))
s6 <- as_sparse6(elm, n = 10)

# To edgelist matrix --------------------------------------------------------
edgelist_from_sparse6(s6)

# To igraph object ----------------------------------------------------------
if(requireNamespace("igraph", quietly=TRUE)) {
  igraph_from_sparse6(s6)
}

# To network object ---------------------------------------------------------
if(requireNamespace("network", quietly=TRUE)) {
  network_from_sparse6(s6)
}

---

graph_as_text

Encode graph as text

Description

Encode a graph as 'graph6', 'sparse6' or 'digraph6' choosing the format automatically.

Usage

graph_as_text(object, ...)

## Default S3 method:
graph_as_text(object, ...)

## S3 method for class 'list'
graph_as_text(object, ...)

Arguments

object       igraph/network object or a list thereof
...
other arguments, currently ignored

Details

If object is a list it may be a mixture of 'network' and 'igraph' objects.

Value

A character vector of encoded graphs.
**igraph_from_text**

Create igraph objects from ‘graph6’, ‘sparse6’, or ‘digraph6’ symbols

**Description**

Create igraph objects from ‘graph6’, ‘sparse6’, or ‘digraph6’ symbols

**Usage**

`igraph_from_text(object)`

**Arguments**

object character vector of ‘graph6’, ‘sparse6’, or ‘digraph6’ symbols

**Methods (by class)**

- `graph_as_text(default)`: The default method chooses the encoding format automatically using `choose_format()`.
- `graph_as_text(list)`: The list method applies the default method to each element.

**See Also**

`choose_format()`

**Examples**

```r
# From igraph -----------------------------------------------
if(requireNamespace("igraph")) {
  g <- igraph::graph.famous("Zachary")
  graph_as_text(g)

  glist <- list(
    igraph::sample_gnp(n = 15, p = 0.1),
    igraph::sample_gnp(n = 15, p = 0.2),
    igraph::sample_gnp(n = 15, p = 0.3))
  graph_as_text(glist)
}

# From network ---------------------------------------------
if(requireNamespace("network")) {
  m <- matrix(rbinom(25,1,.4),5,5)
  diag(m) <- 0
  g <- network::network(m, directed=FALSE)
  graph_as_text(g)
}
```
is_graph6

Value

A list of 'igraph' objects.

Examples

if(requireNamespace("igraph", quietly=TRUE)) {
  # Graph6 symbols
  sampleg6
  igraph_from_text(sampleg6)

  # Sparse6 symbols
  s6 <- c(":DgXI@G~", ":DgWcGcb")
  igraph_from_text(s6)

  # Digraph6 symbol
  d6 <- "&N????C??D?_G??C?????_C_???????C??Q@O?G?"
  igraph_from_text(d6)
}

is_graph6

Infer or test for graph6, sparse6, and digraph6 symbols

Description

Functions is_graph6(), is_sparse6(), and is_digraph6() test if elements of a character vector are valid symbols of particular type.

Function guess_format() tries to guess the type of the symbols used in x.

Usage

is_graph6(x)

is_sparse6(x)

is_digraph6(x)

guess_format(x)

Arguments

x character vector

Value

Logical vector of length equal to length(x) with TRUE if an element is a valid symbol and FALSE otherwise.

Function guess_format() returns a character vector of the same length as x with values "graph6", "sparse6", or "digraph6" depending on the type of symbol present, or NA if the symbol is unknown or matches more than one type.
Note

At this moment the test is performed using regular expressions. Theoretically it may result in false positives.

Examples

```r
all(is_graph6(g6))
all(is_sparse6(s6))
all(is_digraph6(d6))

# Vector mixing graphs in various formats
x <- g6
x[seq(2, 20, by = 3)] <- s6[seq(2, 20, by = 3)]
x[seq(3, 20, by = 3)] <- d6[seq(3, 20, by = 3)]
guess_format(x)
```

**network_from_text**

Create network objects from 'graph6', 'sparse6', or 'digraph6' symbols

**Description**

Create network objects from 'graph6', 'sparse6', or 'digraph6' symbols

**Usage**

```r
network_from_text(object)
```

**Arguments**

- `object` character vector of 'graph6', 'sparse6', or 'digraph6' symbols

**Value**

A list of 'network' objects.

**Examples**

```r
# complete graph in graph6 format
g6 <- "G~~~~{"

# random graph with 15 nodes
s6 <- ":NeF?bsl?aNc"

# random directed graph with 10 nodes
d6 <- ":I??GGGI?_gG???O??"

network_from_text(g6)
network_from_text(c(g6,s6,d6))
```
Description

Read files of 'graph6', 'sparse6' or 'digraph6' symbols

Usage

read_file6(path, type = "adjacency")

Arguments

path character; path to file name

Arguments

path character; path to file name

type character; one of "adjacency", "edgelist", "igraph", or "network". Type of result returned.

Details

File pointed to by path is a text file with one graph symbol per line. Optional headers of the form >>graph6<< or >>sparse6<< in the first line (and without the newline after the header) are ignored and removed.

Value

A list of decoded graphs in the form of objects determined by type.

Examples

```r
g6_file <- tempfile()
write(sampleg6,g6_file)
read_file6(g6_file, type = "adjacency")
unlink(g6_file)
```

Description

Objects g6, s6, and d6 are vectors of codes in 'graph6', 'sparse6', and 'digraph6' representations respectively. Object sampleg6 is a vector of 'graph6' codes.
Usage

g6
s6
d6

sampleg6

Format

The three objects g6, s6, and d6 are character vectors of length 20 corresponding to undirected (in case of g6 and s6) and directed (in case of d6) graphs of varying sizes and densities.

Object sampleg6 is a character vector of length 9 of undirected graphs in ’graph6’ format.

Details

Graphs in g6, s6, and d6 objects were generated using the common algorithm which consists of the following steps:

1. For each value from the vector of sizes of the node set (15, 30, 60, 120)...
2. ... generate a vector of edge counts (size of the edge set) of length 5 ranging from a single edge up to an edge count corresponding to the density of 0.2.
3. Given the node set sizes (item 1) and edge set sizes (item 2) sample undirected graphs from GNM model.
4. These undirected graphs are encoded in g6 and s6
5. Directed graphs were created by turning undirected edges to directed arcs in an arbitrary manner. These are encoded in the d6 object.
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