

Package ‘rgph’

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Type Package

Title Pair Critical Points and Compute Persistent Homology of Reeb Graphs

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Description Interface to the 'ReebGraphPairing' program to compute critical points of Reeb graphs following Tu, Hajij, & Rosen (2019) <[doi:10.1007/978-3-030-33720-9_8](https://doi.org/10.1007/978-3-030-33720-9_8)> via the 'rJava' package. Also store Reeb graphs in a minimal S3 class, convert between other network data structures, and post-process pairing data to obtain extended persistent homology following Carrière & Oudot (2018) <[doi:10.1007/s10208-017-9370-z](https://doi.org/10.1007/s10208-017-9370-z)>.

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as_reeb_graph	<i>Coerce objects to class reeb_graph</i>
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Description

Coerce objects to [reeb_graph]-class objects.

Usage

```
as_reeb_graph(x, ...)

## S3 method for class 'igraph'
as_reeb_graph(x, values = NULL, names = NULL, ...)

## S3 method for class 'network'
as_reeb_graph(x, values = NULL, names = NULL, ...)

as_igraph(x, ...)

## S3 method for class 'reeb_graph'
as_igraph(x, values = "value", names = "name", ...)

as_network(x, ...)

## S3 method for class 'reeb_graph'
as_network(x, values = "value", names = "vertex.names", ...)
```

Arguments

x	An R object to be coerced. See Details.
...	Additional arguments passed to methods.
values	For coercion <i>to</i> class reeb_graph, a character value; the node attribute to use as the Reeb graph value function. If NULL (the default), the first numeric node attribute is used. For coercion <i>from</i> class reeb_graph, a character value; the name of the node attribute in which to store the Reeb graph value function.
names	For coercion <i>to</i> class reeb_graph, a character value; the node attribute to use as the Reeb graph node names. If NULL, names are omitted. For coercion <i>from</i> class reeb_graph, a character value; the name of the node attribute in which to store the Reeb graph node names.

Details

The `as_reeb_graph()` methods require a network (mathematical graph) structure and a real-valued function on the vertex set.

For coercion between external network classes, use the `intergraph` package.

Value

A `reeb_graph` object.

See Also

[reeb_graph\(\)](#)

Examples

```
library(igraph)
( g <- make_kautz_graph(2, 1) )
l_g <- layout_with_fr(g)
plot(g, layout = l_g)
( rg <- as_reeb_graph(g, l_g[, 1]) )
vertex_attr(g, "height") <- rg$value
heights <- sort(unique(V(g)$height))
l_rg <- layout_with_sugiyama(g, layers = round(V(g)$height * 100))
plot(g, layout = l_rg)
```

```
library(network)
data("emon")
mtsi <- emon$Cheyenne
mtsi_reeb <- as_reeb_graph(
  mtsi,
  values = "Command.Rank.Score",
  names = "vertex.names"
)
print(mtsi_reeb, minlength = 24)
```

reeb_graph

An S3 class and constructors for Reeb graphs

Description

This is an S3 class with associated constructors for a data structure to represent Reeb graphs in R.

Usage

```
reeb_graph(values, edgelist)

## S3 method for class 'reeb_graph'
print(x, ..., n = NULL, minlength = 12L)

## S3 method for class 'reeb_graph'
format(x, ..., n = NULL, minlength = 12L)

read_reeb_graph(file)
```

Arguments

values	Numeric vector of function values at vertices; may have names, which may be duplicated and/or missing.
edgelist	2-column integer matrix of linked vertex pairs.
x	Object of class reeb_graph.
...	Additional arguments passed to <code>base::format()</code> .
n	Integer number of edges to print.
minlength	Minimum name abbreviation length; passed to <code>base::abbreviate()</code> .
file	A plain text file containing Reeb graph data formatted as at <code>ReebGraphPairing</code> .

Details

Vertex indices start at zero, for consistency with examples. The positions of values and the integer values in edgelist will correspond to the same vertices; `length(values)` must bound `max(edgelist)`.

The S3 class is a list of "values" and "edgelist". The `print()` method prints one edge per line, with nodes formatted as "index[name] (value)"

Value

An object of class "reeb_graph", which is a list of two elements:

- values: Numeric vector of function values at vertices, optionally named.
- edgelist: 2-column integer matrix of linked vertex pairs.

References

<https://github.com/USFDataVisualization/ReebGraphPairing/>

See Also

[as_reeb_graph\(\)](#)

Examples

```
x <- reeb_graph(  
  values = c(a = 0, b = .4, c = .6, d = 1),  
  edgelist = rbind( c(1,2), c(1,3), c(2,4), c(3,4))  
)  
print(x)  
  
t10 <- system.file("extdata", "10_tree_iterations.txt", package = "rgph")  
( y <- read_reeb_graph(t10) )  
  
reeb_graph_pairs(x, method = "multi_pass")  
reeb_graph_pairs(y, method = "multi_pass")
```

reeb_graph_examples *Mesh-Derived Reeb Graphs*

Description

These are some of the Reeb graphs used by Tu & al (2019; Fig. 8) to benchmark the multi-pass and single-pass algorithms. The original meshes were obtained from the AIM@SHAPE Shape Repository, while the authors computed Reeb graphs using a custom C++ implementation.

Usage

```
david  
buddha  
topology  
flower
```

Format

Objects of class `reeb_graph`.

Source

<http://visionair.ge.imati.cnr.it/ontologies/shapes/> (AIM@SHAPE; defunct) <https://github.com/USFDataVisualization/ReebGraphPairing>

reeb_graph_pairs *Pair Reeb Graph Critical Points via Java*

Description

This function calls one of two methods, merge-pair and propagate-and-pair, to pair the critical points of a Reeb graph.

Usage

```
reeb_graph_pairs(  
  x,  
  sublevel = TRUE,  
  method = c("single_pass", "multi_pass"),  
  ...  
)
```

Default S3 method:

```
reeb_graph_pairs(  
  x,  
  sublevel = TRUE,  
  method = c("single_pass", "multi_pass"),  
  ...  
)
```

S3 method for class 'igraph'

```
reeb_graph_pairs(  
  x,  
  sublevel = TRUE,  
  method = c("single_pass", "multi_pass"),  
  values = NULL,  
  ...  
)
```

S3 method for class 'network'

```
reeb_graph_pairs(  
  x,  
  sublevel = TRUE,  
  method = c("single_pass", "multi_pass"),  
  values = NULL,  
  ...  
)
```

S3 method for class 'reeb_graph'

```
reeb_graph_pairs(  
  x,  
  sublevel = TRUE,
```

```

    method = c("single_pass", "multi_pass"),
    ...
)

## S3 method for class 'reeb_graph_pairs'
as.data.frame(x, ...)

## S3 method for class 'reeb_graph_pairs'
print(x, ..., n = NULL, minlength = 12L)

## S3 method for class 'reeb_graph_pairs'
format(x, ..., n = NULL, minlength = 12L)

```

Arguments

x	A reeb_graph object.
sublevel	Logical; whether to use the sublevel set filtration (TRUE, the default) or else the superlevel set filtration (via reversing <code>x[["values"]]</code>) before paring critical points.
method	Character; the pairing method to use. Matched to "single_pass" (the default) or "multi_pass".
...	Additional arguments passed to methods.
values	For coercion <i>to</i> class <code>reeb_graph</code> , a character value; the node attribute to use as the Reeb graph value function. If NULL (the default), the first numeric node attribute is used. For coercion <i>from</i> class <code>reeb_graph</code> , a character value; the name of the node attribute in which to store the Reeb graph value function.
n	Integer number of critical pairs to print.
minlength	Minimum name abbreviation length; passed to <code>base::abbreviate()</code> .

Details

The function uses the `rJava` package to call either of two Java methods from `ReebGraphPairing`. Ensure the Java Virtual Machine (JVM) is initialized and the required class is available in the class path.

The Propagate-and-Pair algorithm ("single_pass") performs both join and split merge tree operations along a single sweep through the Reeb graph. It was shown to be more efficient on most test data, and to scale better with graph size, than an algorithm ("multi_pass") that pairs some types along the sublevel filtration and others along the superlevel filtration (Tu & al, 2019).

The output S3 class is a list of 2-column matrices containing the types, values, indices, and orders of persistent pairs, with attributes containing the node names and metadata. The `print()` method visually expresses each pair, increasing from left to right, with nodes formatted as with [reeb_graph](#).

The names of the coerced data frame use `lo_` and `hi_` prefixes, in contrast to the Java source code that uses `birth_` and `death_`. This is meant to distinguish the pairs and their metadata from [persistent homology](#), which is here reformulated following Carrière & Oudot (2018).

Value

A list of subclass `reeb_graph_pairs` containing 4 2-column matrices characterizing the low- and high-valued critical points of each pair:

`type` Character; the type of critical point, one of LEAF_MIN, LEAF_MAX, UPFORK, and DOWNFORK.

`value` Double; the value (stored in `x[["values"]]`) of the critical point.

`index` Integer; the index (used in `x[["edgelist"]]`) of the critical point. Regular points will not appear, while degenerate critical points will appear multiple times.

`order` Integer; the order of the critical point in the pairing. This is based on the conditioned Reeb graph constructed internally so will not be duplicated.

The data frame also has attributes `"names"` for the node names, `"method"` for the method used, and `"elapsed_time"` for the elapsed time.

References

<https://github.com/USFDataVisualization/ReebGraphPairing/>

Tu J, Hajij M, Rosen P. Propagate and Pair: A Single-Pass Approach to Critical Point Pairing in Reeb Graphs. In: Bebis G, Boyle R, Parvin B, &al, eds. *Advances in Visual Computing. Lecture Notes in Computer Science*. Springer International Publishing; 2019:99–113. doi:10.1007/9783-030337209_8

Carrière M & Oudot S (2018) "Structure and Stability of the One-Dimensional Mapper". *Foundations of Computational Mathematics* 18(6): 1333–1396. doi:10.1007/s102080179370z

See Also

[reeb_graph_persistence\(\)](#)

Examples

```
ex_sf <- system.file("extdata", "running_example.txt", package = "rgph")
( ex_rg <- read_reeb_graph(ex_sf) )
( ex_cp <- reeb_graph_pairs(ex_rg) )
attr(ex_cp, "method")
attr(ex_cp, "elapsed_time")

reeb_graph_pairs(ex_rg, sublevel = FALSE)

x <- reeb_graph(
  values = c(0, .4, .6, 1),
  edgelist = c( 1,2, 1,3, 2,4, 3,4 )
)
( mp <- reeb_graph_pairs(x) )
class(mp)
as.data.frame(mp)

names(x$values) <- letters[seq_along(x$values)]
( mp <- reeb_graph_pairs(x) )
as.data.frame(mp)
```

```

library(network)
data("emon")
mtsi <- emon$Cheyenne
mtsi_reeb <- as_reeb_graph(
  mtsi,
  values = "Command.Rank.Score",
  names = "vertex.names"
)
mtsi_cp <- reeb_graph_pairs(mtsi_reeb, sublevel = FALSE)
print(mtsi_cp, minlength = 20)

```

reeb_graph_persistence

Compute Extended Persistent Homology of a Reeb Graph

Description

This function obtains extended persistent homology of a Reeb graph by way of pairing critical points.

Usage

```
reeb_graph_persistence(x, scale = c("value", "index", "order"), ...)
```

```
## Default S3 method:
```

```
reeb_graph_persistence(x, scale = c("value", "index", "order"), ...)
```

```
## S3 method for class 'igraph'
```

```
reeb_graph_persistence(
  x,
  scale = c("value", "index", "order"),
  sublevel = TRUE,
  method = c("single_pass", "multi_pass"),
  values = NULL,
  ...
)
```

```
## S3 method for class 'network'
```

```
reeb_graph_persistence(
  x,
  scale = c("value", "index", "order"),
  sublevel = TRUE,
  method = c("single_pass", "multi_pass"),
  values = NULL,
  ...
)
```

```

)

## S3 method for class 'reeb_graph'
reeb_graph_persistence(
  x,
  scale = c("value", "index", "order"),
  sublevel = TRUE,
  method = c("single_pass", "multi_pass"),
  ...
)

## S3 method for class 'reeb_graph_pairs'
reeb_graph_persistence(x, scale = c("value", "index", "order"), ...)

```

Arguments

x	A reeb_graph or reeb_graph_pairs object, or an object that can be coerced to class "reeb_graph" .
scale	Character; the scale parameter used by the persistent pairs. Matched to "value" (the default), "index", or "order".
...	Additional arguments passed to methods.
sublevel	Logical; whether to use the sublevel set filtration (TRUE, the default) or else the superlevel set filtration (via reversing <code>x[["values"]]</code>) before pairing critical points.
method	Character; the pairing method to use. Matched to "single_pass" (the default) or "multi_pass".
values	For coercion <i>to</i> class <code>reeb_graph</code> , a character value; the node attribute to use as the Reeb graph value function. If NULL (the default), the first numeric node attribute is used. For coercion <i>from</i> class <code>reeb_graph</code> , a character value; the name of the node attribute in which to store the Reeb graph value function.

Details

The types, values, and indices of critical pairs are obtained by [reeb_graph_pairs\(\)](#). `reeb_graph_persistence()` calls this function internally with the prescribed method, then restructures the values or indices as [phutil::persistence](#) data.

This function may be deprecated once a `reeb_graph_pairs` method is written for [phutil::as_persistence\(\)](#).

Value

A [phutil::persistence](#) object.

See Also

[reeb_graph_pairs\(\)](#)

Examples

```
ex_sf <- system.file("extdata", "running_example.txt", package = "rgph")
( ex_rg <- read_reeb_graph(ex_sf) )
( ex_ph <- reeb_graph_persistence(ex_rg) )
phutil::get_pairs(ex_ph, dimension = 0)
phutil::get_pairs(ex_ph, dimension = 1)

t10_f <- system.file("extdata", "10_tree_iterations.txt", package = "rgph")
( t10 <- read_reeb_graph(t10_f) )
( t10_ph <- reeb_graph_persistence(t10) )
phutil::get_pairs(t10_ph, dimension = 0)
( t10_ph <- reeb_graph_persistence(t10, scale = "index") )
phutil::get_pairs(t10_ph, dimension = 0)
( t10_ph <- reeb_graph_persistence(t10, scale = "order") )
phutil::get_pairs(t10_ph, dimension = 0)
```

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