Package 'packcircles'

July 23, 2025

Type Package

Version 0.3.7

Title Circle Packing

Description Algorithms to find arrangements of non-overlapping circles.

Date 2024-11-21

URL <https://github.com/mbedward/packcircles>

BugReports <https://github.com/mbedward/packcircles/issues>

Depends R (>= 3.2)

Imports Rcpp (>= 1.0.0), checkmate

Suggests ggiraph (>= 0.8.4), ggplot2, knitr, rmarkdown, lpSolve

VignetteBuilder knitr

LinkingTo Rcpp (>= 1.0.0)

LazyData true

License MIT + file LICENSE

RoxygenNote 7.3.2

Encoding UTF-8

NeedsCompilation yes

Author Michael Bedward [aut, cre],
David Eppstein [aut] (Author of Python code for graph-based circle
packing ported to C++ for this package),
Peter Menzel [aut] (Author of C code for progressive circle packing
ported to C++ for this package)

Maintainer Michael Bedward <michael.bedward@gmail.com>

Repository CRAN

Date/Publication 2024-11-21 08:50:01 UTC

Contents

---

packcircles-package   *packcircles: Simple algorithms for circle packing*

Description

This package provides several algorithms to find non-overlapping arrangements of circles:

circleRepelLayout Arranges circles within a bounding rectangle by pairwise repulsion.

circleProgressiveLayout Arranges circles in an unbounded area by progressive placement. This is a very efficient algorithm that can handle large numbers of circles.

circleGraphLayout Finds an arrangement of circles conforming to a graph specification.

Author(s)

Maintainer: Michael Bedward <michael.bedward@gmail.com>

Authors:

- David Eppstein <david.eppstein@gmail.com> (Author of Python code for graph-based circle packing ported to C++ for this package)

- Peter Menzel <pmenzel@gmail.com> (Author of C code for progressive circle packing ported to C++ for this package)

See Also

Useful links:

- https://github.com/mbedward/packcircles

- Report bugs at https://github.com/mbedward/packcircles/issues

---

bacteria	*Abundance of bacteria*

Description

Names and abundances of bacterial taxa as measured in a study of biofilms.

Usage

```
bacteria
```

Format

'bacteria' A data frame with 167 rows and 3 columns:

value measured abundance

colour preferred colour for display

label taxon name

---

circleGraphLayout	*Find an arrangement of circles satisfying a graph of adjacencies*

Description

Attempts to derive an arrangement of circles satisfying prior conditions for size and adjacency. Unlike the circleRepelLayout function, this is a deterministic algorithm. Circles are classified as either internal or external. Viewing the pattern of adjacencies as a triangulated mesh, external circles are those on the boundary. In the version of the algorithm implemented here, the radii of external circles are provided as inputs, while the radii of internal circles are derived as part of the output arrangement.

Usage

```
circleGraphLayout(internal, external)
```

Arguments

internal	A list of vectors of circle ID values where, in each vector, the first element is the ID of an internal circle and the remaining elements are the IDs of that circle's neighbours arranged as a cycle. The cycle may be clockwise or anti-clockwise but the same ordering must be used for all vectors.
external	A data.frame or matrix of external circle radii, with circle IDs in the first column and radii in the second column.

Details

The `internal` argument specifies circle adjacencies (ie. tangencies). The format is an concise representation of graph edges, and consists of a list of vectors: one per internal circle. In each vector the first element is the ID value of the internal circle and the remaining values are IDs of neighbouring circles, which may be either internal or external.

The `external` argument is a data.frame which specifies the radii of external circles. Internal circle radii should not be specified as they are derived as part of the fitting algorithm. The function will issue an error if any internal circle IDs are present in the `external` data.

Value

A data.frame with columns for circle ID, centre X and Y ordinate, and radius.

The output arrangement as a data.frame with columns for circle ID, centre X and Y ordinates, and radius. For external circles the radius will equal input values.

Note

Please treat this function as experimental.

References

C.R. Collins & K. Stephenson (2003) An algorithm for circle packing. Computational Geometry Theory and Applications 25:233-256.

Examples

```
## Simple example with two internal circles surrounded by
## four external circles. Internal circle IDs are 1 and 2.
internal <- list( c(1, 3, 4, 5), c(2, 3, 4, 6) )

## Uniform radius for external circles
external <- data.frame(id=3:6, radius=1.0)

## Generate the circle packing
packing <- circleGraphLayout(internal, external)
```

---

circleLayout	*Arranges circles by iterative pair-wise repulsion within a bounding rectangle*

Description

This function is deprecated and will be removed in a future release. Please use `circleRepelLayout` instead.

Usage

```
circleLayout(xyr, xlim, ylim, maxiter = 1000, wrap = TRUE, weights = 1)
```

Arguments

xyr	A 3-column matrix or data frame (centre X, centre Y, radius).
xlim	The bounds in the X direction; either a vector for [xmin, xmax) or a single value interpreted as [0, xmax). Alternatively, omitting this argument or passing any of NULL, a vector of NA or an empty vector will result in unbounded movement in the X direction.
ylim	The bounds in the Y direction; either a vector for [ymin, ymax) or a single value interpreted as [0, ymax). Alternatively, omitting this argument or passing any of NULL, a vector of NA or an empty vector will result in unbounded movement in the Y direction.
maxiter	The maximum number of iterations.
wrap	Whether to treat the bounding rectangle as a toroid (default TRUE). When this is in effect, a circle leaving the bounds on one side re-enters on the opposite side.
weights	An optional vector of numeric weights (0 to 1 inclusive) to apply to the distance each circle moves during pair-repulsion. A weight of 0 prevents any movement. A weight of 1 gives the default movement distance. A single value can be supplied for uniform weights. A vector with length less than the number of circles will be silently extended by repeating the final value. Any values outside the range [0, 1] will be clamped to 0 or 1.

Value

A list with components:

layout A 3-column matrix or data.frame (centre x, centre y, radius).

niter Number of iterations performed.

Note

This function assumes that circle sizes are expressed as radii whereas the default for circleRepelLayout is area.

See Also

circleRepelLayout

---

circleLayoutVertices   *Generate a set of circle vertices suitable for plotting*

Description

Given a matrix or data frame for a circle layout, with columns for centre X and Y coordinates and circle sizes, this function generates a data set of vertices which can then be used with ggplot or base graphics functions. If any of the size values in the input data are zero, negative or missing (NA or NULL), the corresponding circles will not be generated. This can be useful when displaying alternative subsets of circles.

Usage

```
circleLayoutVertices(
  layout,
  npoints = 25,
  xysizecols = 1:3,
  sizetype = c("radius", "area"),
  idcol = NULL
)
```

Arguments

layout   A matrix or data frame of circle data (x, y, size). May also contain other columns including an optional identifier column.

npoints   The number of vertices to generate for each circle.

xysizecols   The integer indices or names of columns for the centre X, centre Y and size values. Default is 'c(1,2,3)'.

sizetype   The type of size values: either "radius" (default) or "area". May be abbreviated.

idcol   Optional index (integer) or name (character) of an input data column to use as circle identifier values in the id column of the output data frame. Identifier values may be numeric or character but must be unique. If not provided, the output circle identifiers will be the row numbers of the input circle data.

Value

A data frame with columns: id, x, y; where id is the unique integer identifier for each circle. If no size values in the input layout data are positive, a data frame with zero rows will be returned.

Note

Input sizes are assumed to be radii. This is slightly confusing because the layout functions circleRepelLayout and circleProgressiveLayout treat their input sizes as areas by default. To be safe, you can always set the sizetype argument explicitly for both this function and layout functions.

See Also

[circleVertices](#)

Examples

```
xmax <- 100
ymax <- 100
rmin <- 10
rmax <- 20
N <- 20

## Random centre coordinates and radii
layout <- data.frame(id = 1:N,
                     x = runif(N, 0, xmax),
                     y = runif(N, 0, ymax),
                     radius = runif(N, rmin, rmax))

## Get data for circle vertices
verts <- circleLayoutVertices(layout, idcol=1, xysizecols=2:4,
                              sizetype = "radius")

## Not run:
library(ggplot2)

## Draw circles annotated with their IDs
ggplot() +
  geom_polygon(data = verts, aes(x, y, group = id),
               fill = "grey90",
               colour = "black") +

  geom_text(data = layout, aes(x, y, label = id)) +

  coord_equal() +
  theme_bw()

## End(Not run)
```

---

circlePlotData	*Generate a set of circle vertices suitable for plotting*

Description

This function is deprecated and will be removed in a future release. Please use `circleLayoutVertices` instead.

Usage

```
circlePlotData(layout, npoints = 25, xyr.cols = 1:3, id.col = NULL)
```

Arguments

`layout`	A matrix or data frame of circle data (x, y, radius). May contain other columns, including an optional ID column.
`npoints`	The number of vertices to generate for each circle.
`xyr.cols`	Indices or names of columns for x, y, radius (in that order). Default is columns 1-3.
`id.col`	Optional index or name of column for circle IDs in output. If not provided, the output circle IDs will be the row numbers of the input circle data.

Value

A data frame with columns: id, x, y; where id is the unique integer identifier for each circle.

See Also

[circleLayoutVertices](#) [circleVertices](#)

---

circleProgressiveLayout

Progressive layout algorithm

Description

Arranges a set of circles, which are denoted by their sizes, by consecutively placing each circle externally tangent to two previously placed circles while avoiding overlaps.

Usage

```
circleProgressiveLayout(x, sizecol = 1, sizetype = c("area", "radius"))
```

Arguments

`x`	Either a vector of circle sizes, or a matrix or data frame with one column for circle sizes.
`sizecol`	The index or name of the column in x for circle sizes. Ignored if x is a vector.
`sizetype`	The type of size values: either `"area"` (default) or `"radius"`. May be abbreviated.

Details

Based on an algorithm described in the paper: *Visualization of large hierarchical data by circle packing* by Weixin Wang, Hui Wang, Guozhong Dai, and Hongan Wang. Published in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2006, pp. 517-520 [doi:10.1145/1124772.1124851](https://doi.org/10.1145/1124772.1124851)

The implementation here was adapted from a version written in C by Peter Menzel: https://github.com/pmenzel/packCircles.

Value

A data frame with columns: x, y, radius. If any of the input size values were non-positive or missing, the corresponding rows of the output data frame will be filled with NAs.

Examples

```
areas <- sample(c(4, 16, 64), 100, rep = TRUE, prob = c(60, 30, 10))
packing <- circleProgressiveLayout(areas)

## Not run:

# Graph the result with ggplot
library(ggplot2)

dat.gg <- circleLayoutVertices(packing)

ggplot(data = dat.gg, aes(x, y, group = id)) +
  geom_polygon(colour = "black", fill = "grey90") +
  coord_equal() +
  theme_void()


## End(Not run)
```

---

circleRemoveOverlaps   *Filters a set of circles to remove all overlaps*

Description

Given an initial set of circles, this function identifies a subset of non-overlapping circles using a simple heuristic algorithm. Circle positions remain fixed.

Usage

```
circleRemoveOverlaps(
  x,
  xysizecols = 1:3,
  sizetype = c("area", "radius"),
  tolerance = 1,
  method = c("maxov", "minov", "largest", "smallest", "random", "lparea", "lpnum")
)
```

Arguments

x   A matrix or data frame containing circle x-y centre coordinates and sizes (area
                  or radius).

xysizecols   The integer indices or names of the columns in x for the centre x-y coordinates
                 and sizes of circles. Default is c(1,2,3).

sizetype   The type of size values: either "area" (default) or "radius". May be abbrevi-
                 ated.

tolerance   Controls the amount of overlap allowed. Set to 1 for simple exclusion of over-
                 laps. Values lower than 1 allow more overlap. Values > 1 have the effect of
                 expanding the influence of circles so that more space is required between them.
                 The input value must be > 0.

method   Specifies whether to use linear programming (default) or one of the variants
                 of the heuristic algorithm. Alternatives are: "maxov", "minov", "largest",
                 "smallest", "random", "lparea", "lpnum". See Details for further explana-
                 tion.

Details

The method argument specifies whether to use the heuristic algorithm or linear programming. The
following options select the heuristic algorithm and specify how to choose an overlapping circle to
remove at each iteration:

maxov Choose one of the circles with the greatest number of overlaps.

minov Choose one of the circles with the least number of overlaps.

largest Choose one of the largest circles.

smallest Choose one of the smallest circles.

random Choose a circle at random.

At each iteration the number of overlaps is checked for each candidate circle and any non-overlapping
circles added to the selected subset. Then a single overlapping circle is chosen, based on the method
being used, from among the remainder and marked as rejected. Iterations continue until all circles
have been either selected or rejected. The 'maxov' option (default) generally seems to perform best
at maximizing the number of circles retained. The other options are provided for comparison and
experiment. Beware that some can perform surprisingly poorly, especially 'minov'.

Two further options select linear programming:

lparea Maximise the total area of circles in the subset.

lpnum Maximise the total number of circles in the subset.

The 'lpSolve' package must be installed to use the linear programming options. These options will
find an optimal subset, but for anything other than a small number of initial circles the running time
can be prohibitive.

Value

A data frame with centre coordinates and radii of selected circles.

Note

This function is experimental and will almost certainly change before the next package release. In
particular, it will probably return something other than a data frame.

---

circleRepelLayout	*Arranges circles by iterative pair-wise repulsion within a bounding rectangle*

Description

This function takes a set of circles, defined by a data frame of initial centre positions and radii, and uses iterative pair-wise repulsion to try to find a non-overlapping arrangement where all circle centres lie inside a bounding rectangle. If no such arrangement can be found within the specified maximum number of iterations, the last attempt is returned.

Usage

```
circleRepelLayout(
  x,
  xlim,
  ylim,
  xysizecols = c(1, 2, 3),
  sizetype = c("area", "radius"),
  maxiter = 1000,
  wrap = TRUE,
  weights = 1
)
```

Arguments

x	Either a vector of circle sizes (areas or radii) or a matrix or data frame with a column of sizes and, optionally, columns for initial x-y coordinates of circle centres.
xlim	The bounds in the X direction; either a vector for [xmin, xmax) or a single value interpreted as [0, xmax). Alternatively, omitting this argument or passing any of NULL, a vector of NA or an empty vector will result in unbounded movement in the X direction.
ylim	The bounds in the Y direction; either a vector for [ymin, ymax) or a single value interpreted as [0, ymax). Alternatively, omitting this argument or passing any of NULL, a vector of NA or an empty vector will result in unbounded movement in the Y direction.
xysizecols	The integer indices or names of the columns in x for the centre x-y coordinates and sizes of circles. This argument is ignored if x is a vector. If x is a matrix or data frame but does not contain initial x-y coordinates, this must be indicated as xysizecols = c(NA, NA, 1).
sizetype	The type of size values: either "area" or "radius". May be abbreviated.
maxiter	The maximum number of iterations.
wrap	Whether to treat the bounding rectangle as a toroid (default TRUE). When this is in effect, a circle leaving the bounds on one side re-enters on the opposite side.

weights   An optional vector of numeric weights (0 to 1 inclusive) to apply to the distance
                 each circle moves during pair-repulsion. A weight of 0 prevents any movement.
                 A weight of 1 gives the default movement distance. A single value can be sup-
                 plied for uniform weights. A vector with length less than the number of circles
                 will be silently extended by repeating the final value. Any values outside the
                 range [0, 1] will be clamped to 0 or 1.

Details

The algorithm is adapted from a demonstration app written in the Processing language by Sean Mc-
Cullough (no longer available online). Each circle in the input data is compared to those following
it. If two circles overlap, they are moved apart such that the distance moved by each is proportional
to the radius of the other, loosely simulating inertia. So when a small circle is overlapped by a larger
circle, the small circle moves furthest. This process is repeated until no more movement takes place
(acceptable layout) or the maximum number of iterations is reached (layout failure).

To avoid edge effects, the bounding rectangle can be treated as a toroid by setting the `wrap` argument
to `TRUE`. With this option, a circle moving outside the bounds re-enters at the opposite side.

Value

A list with components:

layout A 3-column matrix or data frame (centre x, centre y, radius).

niter Number of iterations performed.

---

circleVertices   *Generate vertex coordinates for a circle*

Description

Generates vertex coordinates for a circle given its centre coordinates and radius.

Usage

```
circleVertices(xc, yc, radius, npoints = 25)
```

Arguments

xc   Value for centre X ordinate.

yc   Value for centre Y ordinate.

radius   Value for radius.

npoints   The number of distinct vertices required.

Value

A 2-column matrix of X and Y values. The final row is a copy of the first row to create a closed
polygon, so the matrix has npoints + 1 rows.

See Also

circleLayoutVertices

Index