

# Package ‘edgebundle’

January 23, 2022

**Title** Algorithms for Bundling Edges in Networks and Visualizing Flow and Metro Maps

**Version** 0.3.1

**Description** Implements several algorithms for bundling edges in networks and flow and metro map layouts. This includes force directed edge bundling <[doi:10.1111/j.1467-8659.2009.01450.x](https://doi.org/10.1111/j.1467-8659.2009.01450.x)>, a flow algorithm based on Steiner trees<[doi:10.1080/15230406.2018.1437359](https://doi.org/10.1080/15230406.2018.1437359)> and a multicriteria optimization method for metro map layouts <[doi:10.1109/TVCG.2010.24](https://doi.org/10.1109/TVCG.2010.24)>.

**URL** <http://edgebundle.schochastics.net/>,  
<https://github.com/schochastics/edgebundle>

**BugReports** <https://github.com/schochastics/edgebundle/issues>

**License** MIT + file LICENSE

**Suggests** testthat (>= 2.0.0), network, tidygraph

**Config/testthat/edition** 2

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.1.2

**LinkingTo** Rcpp

**Imports** Rcpp, igraph, reticulate, interp

**Depends** R (>= 3.5)

**NeedsCompilation** yes

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**R topics documented:**

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cali2010

*Migration from California in 2010*


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**Description**

A dataset containing the number of people who migrated from California to other US states

**Usage**

```
cali2010
```

**Format**

```
igraph object
```

**Source**

<https://www.census.gov/data/tables/time-series/demo/geographic-mobility/state-to-state-migration.html>

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convert_edges	<i>Convert edges</i>
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**Description**

converts edges of an igraph/network/tidygraph object into format useable for edge bundling

**Usage**

```
convert_edges(object, coords)

## Default S3 method:
convert_edges(object, coords)

## S3 method for class 'igraph'
convert_edges(object, coords)

## S3 method for class 'network'
convert_edges(object, coords)

## S3 method for class 'tbl_graph'
convert_edges(object, coords)
```

**Arguments**

object	graph object
coords	coordinates of vertices

**Value**

data frame of edges with coordinates

**Author(s)**

David Schoch

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edge_bundle_force	<i>force directed edge bundling</i>
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**Description**

Implements the classic edge bundling by Holten.

**Usage**

```
edge_bundle_force(  
  object,  
  xy,  
  K = 1,  
  C = 6,  
  P = 1,  
  S = 0.04,  
  P_rate = 2,  
  I = 50,  
  I_rate = 2/3,  
  compatibility_threshold = 0.6,  
  eps = 1e-08  
)
```

**Arguments**

object	a graph object (igraph/network/tbl_graph)
xy	coordinates of vertices
K	spring constant
C	number of iteration cycles
P	number of initial edge divisions
S	initial step size
P_rate	rate of edge divisions
I	number of initial iterations
I_rate	rate of iteration decrease per cycle
compatibility_threshold	threshold for when edges are considered compatible
eps	accuracy

**Details**

This is a re-implementation of <https://github.com/upphiminn/d3.ForceBundle>. Force directed edge bundling is slow ( $O(E^2)$ ).

see [online](#) for plotting tips

**Value**

data.frame containing the bundled edges

**Author(s)**

David Schoch

## References

Holten, Danny, and Jarke J. Van Wijk. "Force-Directed Edge Bundling for Graph Visualization." Computer Graphics Forum (Blackwell Publishing Ltd) 28, no. 3 (2009): 983-990.

## See Also

[edge\\_bundle\\_hammer](#), [edge\\_bundle\\_stub](#), [edge\\_bundle\\_path](#)

## Examples

```
library(igraph)
g <- graph_from_edgelist(matrix(c(1,12,2,11,3,10,4,9,5,8,6,7), ncol = 2, byrow = TRUE), FALSE)
xy <- cbind(c(rep(0,6), rep(1,6)), c(1:6, 1:6))
edge_bundle_force(g, xy)
```

---

edge_bundle_hammer	<i>hammer edge bundling</i>
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## Description

Implements the hammer edge bundling by Ian Calvert.

## Usage

```
edge_bundle_hammer(object, xy, bw = 0.05, decay = 0.7)
```

## Arguments

object	a graph object (igraph/network/tbl_graph)
xy	coordinates of vertices
bw	bandwidth parameter
decay	decay parameter

## Details

This function only wraps existing python code from the datashader library. Original code can be found at <https://gitlab.com/ianjcalvert/edgehammer>. Datashader is a huge library with a lot of dependencies, so think twice if you want to install it just for edge bundling. Check [https://datashader.org/user\\_guide/Networks.h](https://datashader.org/user_guide/Networks.h) for help concerning parameters bw and decay. To install all dependencies, use [install\\_bundle\\_py](#).

see [online](#) for plotting tips

## Value

data.frame containing the bundled edges

**Author(s)**

David Schoch

**See Also**

[edge\\_bundle\\_force](#), [edge\\_bundle\\_stub](#), [edge\\_bundle\\_path](#)

---

edge\_bundle\_path

*Edge-Path Bundling*

---

**Description**

Implements edge-path bundling.

**Usage**

```
edge_bundle_path(g, xy, max_distortion = 2, weight_fac = 2, segments = 20)
```

**Arguments**

<code>g</code>	an igraph object
<code>xy</code>	coordinates of vertices
<code>max_distortion</code>	maximum distortion
<code>weight_fac</code>	edge weight factor
<code>segments</code>	number of subdivisions of edges

**Details**

This is a re-implementation of <https://github.com/mwallinger-tu/edge-path-bundling>  
see [online](#) for plotting tips

**Value**

data.frame containing the bundled edges

**Author(s)**

David Schoch

**References**

Wallinger, M., Archambault, D., Auber, D., Nollenburg, M., & Peltonen, J. (2021). Edge-Path Bundling: A Less Ambiguous Edge Bundling Approach. *IEEE Transactions on Visualization and Computer Graphics*.

**See Also**

[edge\\_bundle\\_hammer](#), [edge\\_bundle\\_stub](#), [edge\\_bundle\\_force](#)

**Examples**

```
library(igraph)
g <- graph_from_edgelist(matrix(c(1,2,1,6,1,4,2,3,3,4,4,5,5,6), ncol = 2, byrow = TRUE), FALSE)
xy <- cbind(c(0,10,25,40,50,50), c(0,15,25,15,0,-10))
edge_bundle_path(g, xy)
```

---

edge\_bundle\_stub      *stub edge bundling*

---

**Description**

Implements the stub edge bundling by Nocaj and Brandes

**Usage**

```
edge_bundle_stub(
  object,
  xy,
  alpha = 11,
  beta = 75,
  gamma = 40,
  t = 0.5,
  tshift = 0.5
)
```

**Arguments**

object	a graph object (igraph/tbl_graph). Does not support network objects
xy	coordinates of vertices
alpha	maximal angle (in degree) between consecutive edges in a bundle
beta	angle (in degree) at which to connect two stubs
gamma	maximal overall angle (in degree) of an edge bundle
t	numeric between 0 and 1. control point location
tshift	numeric between 0 and 1. The closer to one, the longer the bigger bundle

**Details**

see [online](#) for plotting tips

**Value**

data.frame containing the bundled edges

**Author(s)**

David Schoch

**References**

Nocaj, Arlind, and Ulrik Brandes. "Stub bundling and confluent spirals for geographic networks." International Symposium on Graph Drawing. Springer, Cham, 2013.

**See Also**

[edge\\_bundle\\_hammer](#), [edge\\_bundle\\_force](#), [edge\\_bundle\\_path](#)

**Examples**

```
library(igraph)
g <- graph.star(10, "undirected")

xy <- matrix(c(
  0, 0,
  cos(90*pi/180), sin(90*pi/180),
  cos(80*pi/180), sin(80*pi/180),
  cos(70*pi/180), sin(70*pi/180),
  cos(330*pi/180), sin(330*pi/180),
  cos(320*pi/180), sin(320*pi/180),
  cos(310*pi/180), sin(310*pi/180),
  cos(210*pi/180), sin(210*pi/180),
  cos(200*pi/180), sin(200*pi/180),
  cos(190*pi/180), sin(190*pi/180)
), ncol=2, byrow=TRUE)

edge_bundle_stub(g, xy)
# use ggforce::geom_bezier for plotting
```

---

install\_bundle\_py      *install python dependencies for hammer bundling*

---

**Description**

install datashader and scikit-image

**Usage**

```
install_bundle_py(method = "auto", conda = "auto")
```



**Arguments**

method	Installation method (by default, "auto" automatically finds a method that will work in the local environment, but note that the "virtualenv" method is not available on Windows)
conda	Path to conda executable (or "auto" to find conda using the PATH and other conventional install locations)

---

metro_berlin	<i>Subway network of Berlin</i>
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---

**Description**

A dataset containing the subway network of Berlin

**Usage**

```
metro_berlin
```

**Format**

igraph object

**References**

Kujala, Rainer, et al. "A collection of public transport network data sets for 25 cities." Scientific data 5 (2018): 180089.

---

metro_multicriteria	<i>Metro Map Layout</i>
---------------------	-------------------------

---

**Description**

Metro map layout based on multicriteria optimization

**Usage**

```
metro_multicriteria(object, xy, l = 2, gr = 0.0025, w = rep(1, 5), bsize = 5)
```

**Arguments**

object	original graph
xy	initial layout of the original graph
l	desired multiple of grid point spacing. (l*gr determines desired edge length)
gr	grid spacing. (l*gr determines desired edge length)
w	weight vector for criteria (see details)
bsize	number of grid points a station can move away from its original position

## Details

The function optimizes the following five criteria using a hill climbing algorithm:

- *Angular Resolution Criterion*: The angles of incident edges at each station should be maximized, because if there is only a small angle between any two adjacent edges, then it can become difficult to distinguish between them
- *Edge Length Criterion*: The edge lengths across the whole map should be approximately equal to ensure regular spacing between stations. It is based on the preferred multiple,  $l$ , of the grid spacing,  $g$ . The purpose of the criterion is to penalize edges that are longer than or shorter than  $lg$ .
- *Balanced Edge Length Criterion*: The length of edges incident to a particular station should be similar
- *Line Straightness Criterion*: (not yet implemented) Edges that form part of a line should, where possible, be co-linear either side of each station that the line passes through
- *Octilinearity Criterion*: Each edge should be drawn horizontally, vertically, or diagonally at 45 degree, so we penalize edges that are not at a desired angle see [online](#) for more plotting tips

## Value

new coordinates for stations

## Author(s)

David Schoch

## References

Stott, Jonathan, et al. "Automatic metro map layout using multicriteria optimization." IEEE Transactions on Visualization and Computer Graphics 17.1 (2010): 101-114.

## Examples

```
# the algorithm has problems with parallel edges
library(igraph)
g <- simplify(metro_berlin)
xy <- cbind(V(g)$lon,V(g)$lat)*100

# the algorithm is not very stable. try playing with the parameters
xy_new <- metro_multicriteria(g,xy,l = 2,gr = 0.5,w = c(100,100,1,1,100),bsize = 35)
```

---

 tnss\_dummies

*Sample points for triangulated networks*


---

**Description**

uses various sampling strategies to create dummy nodes for the [tnss\\_tree](#)

**Usage**

```
tnss_dummies(
  xy,
  root,
  circ = TRUE,
  line = TRUE,
  diag = TRUE,
  grid = FALSE,
  rand = FALSE,
  ncirc = 9,
  rcirc = 2,
  nline = 10,
  ndiag = 50,
  ngrid = 50,
  nrand = 50
)
```

**Arguments**

xy	coordinates of "real" nodes
root	root node id
circ	logical. create circular dummy nodes around leafs.
line	logical. create dummy nodes on a straight line between root and leafs.
diag	logical. create dummy nodes diagonally through space.
grid	logical. create dummy nodes on a grid.
rand	logical. create random dummy nodes.
ncirc	numeric. number of circular dummy nodes per leaf.
rcirc	numeric. radius of circles around leaf nodes.
nline	numeric. number of straight line nodes per leaf.
ndiag	numeric. number of dummy nodes on diagonals.
ngrid	numeric. number of dummy nodes per dim on grid.
nrand	numeric. number of random nodes to create.

**Value**

coordinates of dummy nodes

**Author(s)**

David Schoch

**Examples**

```
# dummy nodes for tree rooted in California
xy <- cbind(state.center$x,state.center$y)
xy_dummy <- tnss_dummies(xy,4)
```

---

tnss\_smooth

*Smooth a Steiner tree*

---

**Description**

Converts the Steiner tree to smooth paths

**Usage**

```
tnss_smooth(g, bw = 3, n = 10)
```

**Arguments**

g	Steiner tree computed with <a href="#">tnss_tree</a>
bw	bandwidth of Gaussian Kernel
n	number of extra nodes to include per edge

**Details**

see see [online](#) for tips on plotting the result

**Value**

data.frame containing the smoothed paths

**Author(s)**

David Schoch

**Examples**

```
xy <- cbind(state.center$x,state.center$y)[!state.name%in%c("Alaska","Hawaii"),]
xy_dummy <- tnss_dummies(xy,root = 4)
gtree <- tnss_tree(cali2010,xy,xy_dummy,root = 4,gamma = 0.9)
tree_smooth <- tnss_smooth(gtree,bw = 10,n = 10)
```

---

tnss\_tree                      *Create Steiner tree from real and dummy points*

---

**Description**

creates an approximated Steiner tree for a flow map visualization

**Usage**

```
tnss_tree(  
  g,  
  xy,  
  xydummy,  
  root,  
  gamma = 0.9,  
  epsilon = 0.3,  
  elen = Inf,  
  order = "random"  
)
```

**Arguments**

g	original flow network (must be a one-to-many flow network, i.e star graph). Must have a weight attribute indicating the flow
xy	coordinates of "real" nodes
xydummy	coordinates of "dummy" nodes
root	root node id of the flow
gamma	edge length decay parameter
epsilon	smoothing factor for Douglas-Peucker Algorithm
elen	maximal length of edges in triangulation
order	in which order shortest paths are calculated ("random", "weight", "near", "far")

**Details**

Use [tnss\\_smooth](#) to smooth the edges of the tree

**Value**

approximated Steiner tree from dummy and real nodes as igraph object

**Author(s)**

David Schoch

**References**

Sun, Shipeng. "An automated spatial flow layout algorithm using triangulation, approximate Steiner tree, and path smoothing." AutoCarto, 2016.

**Examples**

```
xy <- cbind(state.center$x, state.center$y)[!state.name%in%c("Alaska", "Hawaii"),]
xy_dummy <- tnss_dummies(xy, root = 4)
gtree <- tnss_tree(cali2010, xy, xy_dummy, root = 4, gamma = 0.9)
```

---

us_flights	<i>Flights within the US</i>
------------	------------------------------

---

**Description**

A dataset containing flights between US airports as igraph object

**Usage**

```
us_flights
```

**Format**

igraph object

**Source**

<https://gist.githubusercontent.com/mbostock/7608400/raw>

---

us_migration	<i>Migration within the US 2010-2019</i>
--------------	--

---

**Description**

A dataset containing the number of people migrating between US states from 2010-2019

**Usage**

```
us_migration
```

**Format**

data.frame

**Source**

<https://www.census.gov/data/tables/time-series/demo/geographic-mobility/state-to-state-migration.html>

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