Package ‘priorCON’

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Type Package

Title Graph Community Detection Methods into Systematic Conservation Planning

Version 0.1.1

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Description An innovative tool-set that incorporates graph community detection methods into systematic conservation planning. It is designed to enhance spatial prioritization by focusing on the protection of areas with high ecological connectivity. Unlike traditional approaches that prioritize individual planning units, 'priorCON' focuses on clusters of features that exhibit strong ecological linkages. The 'priorCON' package is built upon the 'prioritizr' package <doi:10.32614/CRAN.package.prioritizr>, using commercial and open-source exact algorithm solvers that ensure optimal solutions to prioritization problems.

License GPL-3

Encoding UTF-8

URL https://github.com/cadam00/priorCON

BugReports https://github.com/cadam00/priorCON/issues

Imports utils, prioritizr (>= 8.0.4), terra (>= 1.7.78), highs, tmap (>= 3.3.4), sf (>= 1.0.16), brainGraph (>= 3.1.0), igraph (>= 2.0.3)

RoxygenNote 7.3.2

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

Config/testthat/edition 3

VignetteBuilder knitr, rmarkdown

NeedsCompilation no

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Repository CRAN

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Contents

`basic_scenario` *Basic scenario problem*

Description

Solve an ordinary **prioritizr** prioritization problem.

Usage

```
basic_scenario(cost_raster, features_rasters, budget_perc)
```

Arguments

`cost_raster`	`SpatRaster` object used as cost for prioritization. Its coordinates must correspond to the input given at preprocess_graphs.
`features_rasters`	features `SpatRaster` object used for prioritization. Its coordinates must correspond to the input given at preprocess_graphs.
`budget_perc`	`numeric` value $[0, 1]$. It represents the budget percentage of the cost to be used for prioritization.

Details

A basic prioritization problem is created and solved using **prioritizr** package. The solver used for solving the problems is the best available on the computer, following the solver hierarchy of **prioritizr**. By default, the **highs** package using the HiGHS solver is downloaded during package installation.

Value

A list containing input for get_outputs.

References

Hanson, Jeffrey O, Richard Schuster, Nina Morrell, Matthew Strimas-Mackey, Brandon P M Edwards, Matthew E Watts, Peter Arcese, Joseph Bennett, and Hugh P Possingham. 2024. prioritizr: Systematic Conservation Prioritization in R. https://prioritizr.net.

Huangfu, Qi, and JA Julian Hall. 2018. Parallelizing the Dual Revised Simplex Method. *Mathematical Programming Computation* 10 (1): 119–42. doi:10.1007/s1253201701305

See Also

`preprocess_graphs`,`get_metrics`

Examples

```
# Read connectivity files from folder and combine them
combined_edge_list <- preprocess_graphs(system.file("external", package="priorCON"),
                                        header = FALSE, sep =";")

# Set seed for reproducibility
set.seed(42)

cost_raster <- get_cost_raster()
features_rasters <- get_features_raster()

# Solve an ordinary prioritizr prioritization problem
basic_solution <- basic_scenario(cost_raster=cost_raster,
features_rasters=features_rasters, budget_perc=0.1)
```

`connectivity_scenario` *Connectivity scenario problem*

Description

Solve a **prioritizr** prioritization problem, by incorporating graph connectivity of the features.

Usage

```
connectivity_scenario(cost_raster, features_rasters = NULL, budget_perc,
                      pre_graphs)
```

Arguments

`cost_raster`	`SpatRaster` object used as cost for prioritization. Its coordinates must correspond to the input given at preprocess_graphs.
`features_rasters`	features `SpatRaster` object used for prioritization. Its coordinates must correspond to the input given at preprocess_graphs.
`budget_perc`	`numeric` value $[0, 1]$. It represents the budget percentage of the cost to be used for prioritization.
`pre_graphs`	output of get_metrics function.

Details

A connectivity prioritization problem is created and solved using **prioritizr** package. The solver used for solving the problems is the best available on the computer, following the solver hierarchy of **prioritizr**. By default, the **highs** package using the HiGHS solver is downloaded during package installation.

Value

A list containing input for get_outputs.

References

Hanson, Jeffrey O, Richard Schuster, Nina Morrell, Matthew Strimas-Mackey, Brandon P M Edwards, Matthew E Watts, Peter Arcese, Joseph Bennett, and Hugh P Possingham. 2024. prioritizr: Systematic Conservation Prioritization in R. https://prioritizr.net.

Huangfu, Qi, and JA Julian Hall. 2018. Parallelizing the Dual Revised Simplex Method. *Mathematical Programming Computation* 10 (1): 119–42. doi:10.1007/s1253201701305

See Also

`preprocess_graphs`,`get_metrics`

Examples

```
# Read connectivity files from folder and combine them
combined_edge_list <- preprocess_graphs(system.file("external", package="priorCON"),
                                        header = FALSE, sep =";")

# Set seed for reproducibility
set.seed(42)

# Detect graph communities using the s-core algorithm
pre_graphs <- get_metrics(combined_edge_list, which_community = "s_core")

cost_raster <- get_cost_raster()
features_rasters <- get_features_raster()

# Solve a prioritizr prioritization problem,
# by incorporating graph connectivity of the features
connectivity_solution <- connectivity_scenario(cost_raster=cost_raster,
features_rasters=features_rasters, budget_perc=0.1, pre_graphs=pre_graphs)
```

`get_cost_raster` *Cost raster example*

Description

Cost raster example.

Usage

```
get_cost_raster()
```

Value

A cost `SpatRaster` object to use for examples.

Examples

```
library(tmap)

## Import features_raster
cost_raster <- get_cost_raster()

## Plot with tmap
tm_shape(cost_raster) +
  tm_raster(title = "cost")
```

---

get_features_raster *Features raster example*

Description

Features raster example.

Usage

```
get_features_raster()
```

Value

A features `SpatRaster` object to use for examples.

Examples

```
library(tmap)

## Import features_raster
features_raster <- get_features_raster()

## Plot with tmap
tm_shape(features_raster) +
  tm_raster(title = "f1")
```

get_metrics *Detect graph communities for each biodiversity feature.*

Description

Detect graph communities for each biodiversity feature.

Usage

```
get_metrics(connect_mat, which_community = "s_core")
```

Arguments

connect_mat	a data.frame object where the edge lists are contained. See more in details.
which_community	character value for community type detection. It can be one of "s_core", "louvain", "walktrap", "eigen", "betw", "deg" or "page_rank". The default is "s_core".

Details

Function get_metrics is used to calculate graph metrics values. The edge lists created from the previous step, or inserted directly from the user are used in this step to create graphs. The directed graphs are transformed to undirected. The function is based on the **igraph** package which is used to create clusters using Louvain and Walktrap and calculate the following metrics: Eigenvector Centrality, Betweenness Centrality and Degree. S-core is calculated using the package **brainGraph**.

connect_mat is either the output of preprocess_graphs or a custom edge list data.frame object, with the following columns:

- feature: feature name.
- from.X: longitude of the origin (source).
- from.Y: latitude of the origin (source).
- to.X: longitude of the destination (target).
- to.Y: latitude of the destination (target).
- weight: connection weight.

Value

A list containing input for basic_scenario or connectivity_scenario.

References

Csárdi, Gábor, and Tamás Nepusz. 2006. The Igraph Software Package for Complex Network Research. *InterJournal Complex Systems*: 1695. https://igraph.org.

Csárdi, Gábor, Tamás Nepusz, Vincent Traag, Szabolcs Horvát, Fabio Zanini, Daniel Noom, and Kirill Müller. 2024. igraph: Network Analysis and Visualization in R. doi:10.5281/zenodo.7682609.

Watson, Christopher G. 2024. brainGraph: Graph Theory Analysis of Brain MRI Data. doi:10.32614/CRAN.package.brainGraph.

See Also

preprocess_graphs, get_metrics

Examples

```
# Read connectivity files from folder and combine them
combined_edge_list <- preprocess_graphs(system.file("external",
                                        package="priorCON"),
                                        header = FALSE, sep =";")

# Set seed for reproducibility
set.seed(42)

# Detect graph communities using the s-core algorithm
pre_graphs <- get_metrics(combined_edge_list, which_community = "s_core")
```

---

get_outputs *Evaluate outputs*

Description

Evaluate outputs from basic_scenario or connectivity_scenario functions for a selected feature.

Usage

```
get_outputs(solution, feature, pre_graphs, loose = FALSE, patch = FALSE)
```

Arguments

`solution`	output from basic_scenario or connectivity_scenario functions.
`feature`	`character` with a single feature name used for plots.
`pre_graphs`	output of get_metrics function.
`loose`	use loose or strict graph community connectivity definition. See more in details.
`patch`	`logical` value. If `patch = TRUE`, then different colors can be used for each distinct patch at output plots.

Details

Loose graph connectivity indicates the case where two protected nodes (cells) can be considered connected, even if the between them cells are not protected (thus not included in the solution), whereas strict connectivity indicates the case where two protected cells can be considered connected, only if they are cells between them that are also protected. The default is `loose = FALSE`, indicating the use of the strict connectivity definition.

Value

A list containing the following items:

- tmap: tmap plot of the solution including connections.
- solution: **terra** `SpatRaster` object representing the prioritization solution.
- connections: **sf** `LINESTRING` object representing the preserved connections of the solution.
- connectivity_table: `data.frame` containing all feature names at the first column, the relative held percentages at the second column and the percentage of connections held at the third column.

References

Hijmans, Robert J. 2024. terra: Spatial Data Analysis. doi:10.32614/CRAN.package.terra.

Pebesma, Edzer. 2018. Simple Features for R: Standardized Support for Spatial Vector Data. *The R Journal* 10 (1): 439–46. doi:10.32614/RJ2018009.

Pebesma, Edzer, and Roger Bivand. 2023. Spatial Data Science: With applications in R. *Chapman and Hall/CRC*. doi:10.1201/9780429459016

See Also

`basic_scenario`, `connectivity_scenario`

Examples

```
# Read connectivity files from folder and combine them
combined_edge_list <- preprocess_graphs(system.file("external", package="priorCON"),
                                        header = FALSE, sep =";")

# Set seed for reproducibility
set.seed(42)

# Detect graph communities using the s-core algorithm
pre_graphs <- get_metrics(combined_edge_list, which_community = "s_core")

cost_raster <- get_cost_raster()
features_rasters <- get_features_raster()

# Solve a prioritizr prioritization problem, by incorporating graph connectivity of the features
connectivity_solution <- connectivity_scenario(
                           cost_raster      = cost_raster,
                           features_rasters = features_rasters,
```

```
                            budget_perc       = 0.1,
                            pre_graphs        = pre_graphs
                          )

# Get outputs from connectivity_scenario function for feature "f1"
connectivity_outputs <- get_outputs(solution   = connectivity_solution,
                                    feature    = "f1",
                                    pre_graphs = pre_graphs)

# Plot tmap
connectivity_outputs$tmap

# Print summary of features and connections held percentages for connectivity scenario
print(connectivity_outputs$connectivity_table)
##   feature relative_held connections(%)
## 1      f1     0.1637209      0.3339886
```

`preprocess_graphs` *Read connectivity data from multiple sub-folders.*

Description

Read connectivity data from multiple sub-folders.

Usage

```
preprocess_graphs(path, ...)
```

Arguments

`path`	a path of the folder where sub-folders containing txt or csv files are contained. Each sub-folder has the name of the corresponding connectivity data. In case that a connectivity folder corresponds to a specific biodiversity feature, it should be named as the corresponding feature.
`...`	additional arguments passed to `read.csv`.

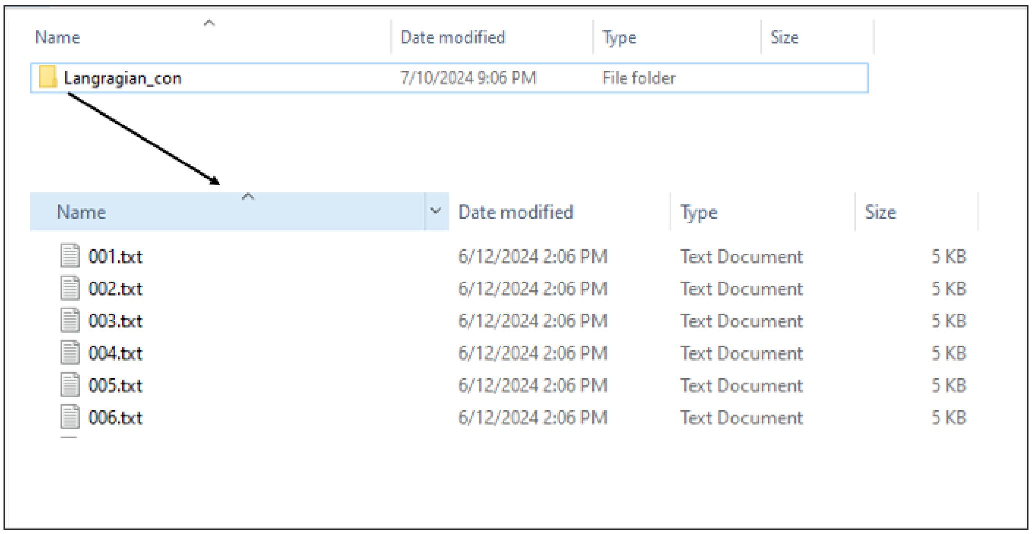
Details

This is an auxiliary function for creating an edge list `data.frame` object from multiple files, like the ones provided from softwares estimating Lagrangian models.

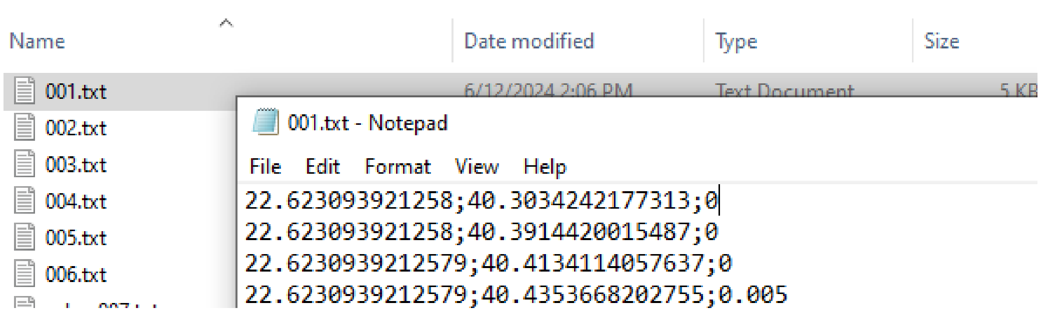
Function preprocess_graphs takes as input a list of .txt/.csv objects. Each object represents the connections between a node and all the other nodes. For the model to read the data, it is necessary to have all the .txt/.csv objects in one folder. There are two ways to incorporate connectivity data, based on their linkage to features:

- Case 1: the connectivity data correspond to specific biodiversity features. If a biodiversity feature has its own connectivity dataset then the file including the edge lists needs to have the same name as the corresponding feature. For example, consider having 5 species (f1, f2, f3, f4, f5) and 5 connectivity datasets. Then the connectivity datasets need to be in separate folders named: f1,f2,f3,f4,f5 and the algorithm will understand that they correspond to the species.

- Case 2: the connectivity dataset represents a spatial pattern that is not directly connected with a specific biodiversity feature. Then the connectivity data need to be included in a separate folder named in a different way than the species. For example consider having 5 species (f1,f2,f3,f4,f5) and 1 connectivity dataset. This dataset can be included in a separate folder (e.g. "Langragian_con").



A typical Lagrangian output is a set of files representing the likelihood of a point moving from an origin (source) to a destination (target). This can be represented using a list of .txt/.csv files (as many as the origin points) including information for the destination probability. The .txt/.csv files need to be named in an increasing order. The name of the files need to correspond to the numbering of the points, in order for the algorithm to match the coordinates with the points.



Value

an edge list `data.frame` object, with the following columns:

- `feature`: feature name.
- `from.X`: longitude of the origin (source).

- `from.Y`: latitude of the origin (source).
- `to.X`: longitude of the destination (target).
- `to.Y`: latitude of the destination (target).
- `weight`: connection weight.

See Also

preprocess_graphs, get_metrics

Examples

```
# Read connectivity files from folder and combine them
combined_edge_list <- preprocess_graphs(system.file("external",
                                        package="priorCON"),
                                        header = FALSE, sep =";")
head(combined_edge_list)

##   feature   from.X   from.Y     to.X     to.Y weight
## 1      f1 22.62309 40.30342 22.62309 40.30342  0.000
## 2      f1 22.62309 40.30342 22.62309 40.39144  0.000
## 3      f1 22.62309 40.30342 22.62309 40.41341  0.000
## 4      f1 22.62309 40.30342 22.62309 40.43537  0.005
## 5      f1 22.62309 40.30342 22.62309 40.45731  0.000
## 6      f1 22.62309 40.30342 22.65266 40.30342  0.000
```

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