Package 'flowcluster'

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Title Cluster Origin-Destination Flow Data

Version 0.2.2

Description Provides functionality for clustering origin-destination (OD) pairs, representing desire lines (or flows). This includes creating distance matrices between OD pairs and passing distance matrices to a clustering algorithm. See the academic paper Tao and Thill (2016) <doi:10.1111/gean.12100> for more details on spatial clustering of flows. See the paper on delineating demand-responsive operating areas by Mahfouz et al. (2025) <doi:10.1016/j.urbmob.2025.100135> for an example of how this package can be used to cluster flows for applied transportation research.

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URL https://hussein-mahfouz.github.io/flowcluster/, https://github.com/hussein-mahfouz/flowcluster

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`add_flow_length` *Add Length Column to Flow Data*

Description

Also checks that 'origin' and 'destination' columns are present.

Usage

```
add_flow_length(x)
```

Arguments

x	sf object of flows (LINESTRING, projected CRS)

Value

sf object with an additional length_m column (od length in meters)

Examples

```
flows <- sf::st_transform(flows_leeds, 3857)
flows <- add_flow_length(flows)
```

add_xyuv *Add Start/End Coordinates & Flow IDs*

Description

Add Start/End Coordinates & Flow IDs

Usage

```
add_xyuv(x)
```

Arguments

x	sf object of flows

Value

tibble with x, y, u, v, flow_ID columns

Examples

```
flows <- sf::st_transform(flows_leeds, 3857)
flows <- add_flow_length(flows)
flows <- add_xyuv(flows)
```

aggregate_clustered_flows *Aggregate clustered OD flows into representative lines*

Description

This function aggregates flows within clusters and creates a single representative line for each cluster. The start and end coordinates are computed as weighted averages (weighted by flow counts or another variable), or simple means if no weights are provided. Each cluster is represented by one `LINESTRING`.

Usage

```
aggregate_clustered_flows(flows, weight = NULL, crs = sf::st_crs(flows))
```

Arguments

`flows`	An `sf` object containing OD flows with coordinates for origins (`x`, `y`) and destinations (`u`, `v`), a `cluster` column, and optionally a `count` or other weighting variable.
`weight`	(optional) Name of a column in `flows` to use for weighting. If `NULL` (default), unweighted means are used.
`crs`	Coordinate reference system for the output (default: taken from `flows`).

Value

An `sf` object with one line per cluster, containing:

- `count_total`: total weight (if provided), otherwise number of flows
- `size`: the cluster size (from the input, not recomputed)
- `geometry`: a `LINESTRING` representing the aggregated OD flow

Examples

```
# ----- 1. Basic Usage: A quick, runnable example ---
# This demonstrates the function with minimal, fast data preparation.
flows <- flowcluster::flows_leeds

# Create the required input columns in a single, fast pipeline
flows_clustered <- flows |>
  add_xyuv() |>
  # Manually create 3 dummy clusters for demonstration
  dplyr::mutate(cluster = sample(1:3, size = nrow(flows), replace = TRUE)) |>
  # The function requires a 'size' column, so we add it
  dplyr::group_by(cluster) |>
  dplyr::add_tally(name = "size") |>
  dplyr::ungroup()

# Demonstrate the function
flows_agg_w <- aggregate_clustered_flows(flows_clustered, weight = "count")
print(flows_agg_w)

# ----- 2. Detailed Workflow (not run by default) ---
## Not run:
  # This example shows the ideal end-to-end workflow, from raw data
  # to clustering and finally aggregation. It is not run during checks
  # because the clustering steps are too slow.

  # a) Prepare the data by filtering and adding coordinates
  flows_prep <- flowcluster::flows_leeds |>
    sf::st_transform(3857) |>
    add_flow_length() |>
    filter_by_length(length_min = 5000, length_max = 12000) |>
    add_xyuv()

  # b) Calculate distances and cluster the flows
  distances <- flow_distance(flows_prep, alpha = 1.5, beta = 0.5)
  dmat <- distance_matrix(distances)
  wvec <- weight_vector(dmat, flows_prep, weight_col = "count")
 flows_clustered_real <- cluster_flows_dbscan(dmat, wvec, flows_prep, eps = 8, minPts = 70)

  # c) Filter clusters and add a 'size' column
  flows_clustered_real <- flows_clustered_real |>
    dplyr::filter(cluster != 0) |> # Filter out noise points
    dplyr::group_by(cluster) |>
    dplyr::mutate(size = dplyr::n()) |>
    dplyr::ungroup()
```

```
# d) Now, use the function on the clustered data
flows_agg_real <- aggregate_clustered_flows(flows_clustered_real, weight = "count")
print(flows_agg_real)

# e) Visualize the results
if (requireNamespace("tmap", quietly = TRUE)) {
  library(tmap)
  # This plot uses modern tmap v4 syntax.
  tm_shape(flows_clustered_real, facet = "cluster") +
    tm_lines(col = "grey50", alpha = 0.5) +
  tm_shape(flows_agg_real) +
    tm_lines(col = "red", lwd = 2) +
  tm_layout(title = "Original Flows (Grey) and Aggregated Flows (Red)")
}

## End(Not run)
```

`cluster_flows_dbscan` *Cluster Flows using DBSCAN*

Description

See dbscan for details on the DBSCAN algorithm.

Usage

```
cluster_flows_dbscan(dist_mat, w_vec, x, eps, minPts)
```

Arguments

`dist_mat`	distance matrix
`w_vec`	weight vector
`x`	flows tibble with flow_ID
`eps`	DBSCAN epsilon parameter
`minPts`	DBSCAN minPts parameter

Value

flows tibble with an additional cluster column

Examples

```
flows <- sf::st_transform(flows_leeds, 3857)
flows <- head(flows, 100) # for testing
# Add flow lengths and coordinates
flows <- add_flow_length(flows)
# filter by length
```

```
flows <- filter_by_length(flows, length_min = 5000, length_max = 12000)
flows <- add_xyuv(flows)
# Calculate distances
distances <- flow_distance(flows, alpha = 1.5, beta = 0.5)
dmat <- distance_matrix(distances)
wvec <- weight_vector(dmat, flows, weight_col = "count")
clustered <- cluster_flows_dbscan(dmat, wvec, flows, eps = 8, minPts = 70)
```

`dbscan_sensitivity` *Sensitivity analysis of DBSCAN parameters for flow clustering.*

Description

The function allows you to test different combinations of epsilon and minPts parameters for clustering flows using DBSCAN. It can be used to determine what parameter values make sense for your data

Usage

```
dbscan_sensitivity(
  dist_mat,
  flows,
  options_epsilon,
  options_minpts,
  w_vec = NULL
)
```

Arguments

`dist_mat`	a precalculated distance matrix between desire lines (output of distance_matrix())
`flows`	the original flows tibble (must contain flow_ID and 'count' column)
`options_epsilon`	a vector of options for the epsilon parameter
`options_minpts`	a vector of options for the minPts parameter
`w_vec`	Optional precomputed weight vector (otherwise computed internally from 'count' column)

Value

a tibble with columns: id (to identify eps and minpts), cluster, size (number of desire lines in cluster), count_sum (total count per cluster)

Examples

```
flows <- sf::st_transform(flows_leeds, 3857)
flows <- head(flows, 1000) # for testing
# Add flow lengths and coordinates
flows <- add_flow_length(flows)
# filter by length
flows <- filter_by_length(flows, length_min = 5000, length_max = 12000)
# Add x, y, u, v coordinates to flows
flows <- add_xyuv(flows)
# Calculate distance matrix
distances <- flow_distance(flows, alpha = 1.5, beta = 0.5)
dmat <- distance_matrix(distances)
# Generate weight vector
w_vec <- weight_vector(dmat, flows, weight_col = "count")

# Define the parameters for sensitivity analysis
options_epsilon <- seq(1, 10, by = 2)
options_minpts <- seq(10, 100, by = 10)
# # Run the sensitivity analysis
results <- dbscan_sensitivity(
  dist_mat = dmat,
  flows = flows,
  options_epsilon = options_epsilon,
  options_minpts = options_minpts,
  w_vec = w_vec
)
```

`distance_matrix` *Convert Long-Format Distance Tibble to Matrix*

Description

Convert Long-Format Distance Tibble to Matrix

Usage

```
distance_matrix(distances, distance_col = "fds")
```

Arguments

`distances`	tibble with columns flow_ID_a, flow_ID_b, and distance
`distance_col`	column name for distance (default "fds")

Value

distance matrix (tibble with rownames). The matrix has flow_ID_a as rownames and flow_ID_b as column names. This function converts the output of `flow_distance()` into a format suitable for the dbscan clustering algorithm.

Examples

```
flows <- sf::st_transform(flows_leeds, 3857)
flows <- head(flows, 100) # for testing
# Add flow lengths and coordinates
flows <- add_flow_length(flows)
flows <- add_xyuv(flows)
# Calculate distances
distances <- flow_distance(flows, alpha = 1.5, beta = 0.5)
dmat <- distance_matrix(distances)
```

`filter_by_length` *Filter Flows by Length*

Description

Filter Flows by Length

Usage

```
filter_by_length(x, length_min = 0, length_max = Inf)
```

Arguments

`x`	sf object with length_m
`length_min`	minimum length (default 0)
`length_max`	maximum length (default Inf)

Value

filtered sf object. Flows with length_m outside the specified range are removed.

Examples

```
flows <- sf::st_transform(flows_leeds, 3857)
flows <- add_flow_length(flows)
flows <- filter_by_length(flows, length_min = 5000, length_max = 12000)
```

flows_leeds *Example flow data for Leeds. It is from the 2021 census, and it contains all Origin - Destination flows at the MSOA level. For more info on census flow data, see the* R*hrefhttps://www.ons.gov.uk/census/aboutcensus/censusproducts/origindestinationflowdataONS documentation See data-raw/flows_leeds.R for how this data was created.*

Description

Example flow data for Leeds. It is from the 2021 census, and it contains all Origin - Destination flows at the MSOA level. For more info on census flow data, see the ONS documentation See data-raw/flows_leeds.R for how this data was created.

Usage

```
flows_leeds
```

Format

An object of class `sf` with LINESTRING geometry. It has the following columns:

origin MSOA code of origin zone

destination MSOA code of destination zone

count number of people moving from origin to destination

geometry desire line between origin and destination

Source

https://www.nomisweb.co.uk/sources/census_2021_od

flow_distance *Calculate Flow Distance and Dissimilarity*

Description

This function calculates flow distance and dissimilarity measures between all pairs of flows based on the method described in @tao2016spatial.

Usage

```
flow_distance(x, alpha = 1, beta = 1)
```

Arguments

x	tibble with flow_ID, x, y, u, v, length_m
alpha	numeric, origin weight
beta	numeric, destination weight

Value

tibble of all OD pairs with fd, fds columns

References

Tao, R., Thill, J.-C., 2016. Spatial cluster detection in spatial flow data. Geographical Analysis 48, 355–372. https://doi.org/10.1111/gean.12100

Examples

```
flows <- sf::st_transform(flows_leeds, 3857)
flows <- head(flows, 100) # for testing
# Add flow lengths and coordinates
flows <- add_flow_length(flows)
flows <- add_xyuv(flows)
# Calculate distances
distances <- flow_distance(flows, alpha = 1.5, beta = 0.5)
```

---

weight_vector *Generate Weight Vector from Flows*

Description

Generate Weight Vector from Flows

Usage

```
weight_vector(dist_mat, x, weight_col = "count")
```

Arguments

dist_mat	distance matrix
x	flows tibble with flow_ID and weight_col
weight_col	column to use as weights (default = "count")

Value

numeric weight vector. Each element corresponds to a flow in the distance matrix, and is used as a weight in the DBSCAN clustering algorithm.

Examples

```
flows <- sf::st_transform(flows_leeds, 3857)
flows <- head(flows, 100) # for testing
# Add flow lengths and coordinates
flows <- add_flow_length(flows)
flows <- add_xyuv(flows)
# Calculate distances
distances <- flow_distance(flows, alpha = 1.5, beta = 0.5)
dmat <- distance_matrix(distances)
wvec <- weight_vector(dmat, flows, weight_col = "count")
```

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