Package ‘stopdetection’

April 18, 2023

Title Stop Detection in Timestamped Trajectory Data using Spatiotemporal Clustering

Version 0.1.2

Description Trajectory data formed by human or animal movement is often marked by periods of movement interspersed with periods of standing still. It is often of interest to researchers to separate geolocation trajectories of latitude/longitude points by clustering consecutive locations to produce a model of this behavior. This package implements the Stay Point detection algorithm originally described in Ye (2009) <doi:10.1109/MDM.2009.11> that uses time and distance thresholds to characterize spatial regions as ‘stops’. This package also implements the concept of merging described in Montoliu (2013) <doi:10.1007/s11042-011-0982-z> as stay point region estimation, which allows for clustering of temporally adjacent stops for which distance between the midpoints is less than the provided threshold. GPS-like data from various sources can be used, but the temporal thresholds must be considered with respect to the sampling interval, and the spatial thresholds must be considered with respect to the measurement error.

License GPL (>= 3)

Encoding UTF-8

RoxygenNote 7.2.1

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

Config/testthat/edition 3

Imports data.table, geodist, lubridate, stats

Depends R (>= 2.10)

LazyData true

VignetteBuilder knitr

URL https://github.com/daniellemccool/stopdetection

BugReports https://github.com/daniellemccool/stopdetection/issues

NeedsCompilation no

Author McCool Danielle [aut, cre] (<https://orcid.org/0000-0002-7055-7539>)
Maintainer  McCool Danielle <d.m.mccool@uu.nl>
Repository  CRAN
Date/Publication  2023-04-18 11:00:02 UTC

R topics documented:

loc_data_2019 ................................................. 2
mergingCycle ................................................. 3
moveMerger .................................................... 4
radiusOfGyrationDT ................................. 5
returnStateEvents ........................................ 6
stopFinder ..................................................... 7
stopMerger .................................................... 8

Index 9

loc_data_2019  Timestamped Location Data

Description

Real data from November 2019 extracted from Google Location History files captured with an Android smartphone. Contains two weeks of human movement behavior of a single person occurring in the Netherlands. Modes include biking, walking, bus and train.

Usage

loc_data_2019

Format

loc_data_2019:
A data frame with 21,911 rows and 3 columns:

latitude  unprojected latitude coordinate using WGS84 ellipsoid
longitude  unprojected longitude coordinate using WGS84 ellipsoid
timestamp  POSIXct timestamp with date and time using fractional seconds ...

Source

Personal recorded location history
mergingCycle

Description

Runs the stop and merging cycle until no changes are seen or until the max number of merges are met.

Usage

mergingCycle(
  res,
  max_merges = Inf,
  thetaD = 200,
  small_track_action = "merge",
  ...
)

Arguments

res Results data.table from stopFinder containing columns timestamp, longitude, latitude and state
max_merges integer of maximum number of merges to perform
thetaD how many meters away may stops be and still be merged
small_track_action one of "merge" or "exclude" for short tracks
... additional optional arguments passed to moveMerger including max_locs, max_time and max_dist

Value

Modifies res data.table by reference

Examples

# Load data
library(data.table)
data(loc_data_2019); setDT(loc_data_2019)
# Find initial set of stops
stopFinder(loc_data_2019, thetaD = 200, thetaT = 300)
# This selection contains two short tracks to eliminate and two stops to merge
events_pre_merge <- returnStateEvents(example)
# Perform the merging
mergingCycle(example, thetaD = 200, small_track_action = "exclude", max_locs = Inf)
events_post_merge <- returnStateEvents(example)
# From 11 states to 8 states
moveMerger

Description
Handles move/track events that do not meet specific thresholds to be considered. This is based on the researcher-decided total number of allowable locations that the discarded track can consist of, as well as a maximum total time length that may elapse. Tracks can be merged into the preceding stop or excluded. Future versions of this should consider assigning to the closest stop for `small_track_action = merge`.

Usage
```r
moveMerger(
  events,
  small_track_action = "merge",
  max_locs = 1,
  max_time = 600,
  max_dist = 100
)
```

Arguments
- `events` data.table of events from `returnStateEvents`
- `small_track_action` One of "merge" or "exclude" for specifying the method of handling mergeable tracks
- `max_locs` Maximum number of locations for a track to be mergeable. Set to Inf to not consider.
- `max_time` Maximum time elapsed (seconds) for a track to be mergeable. Set to Inf to not consider.
- `max_dist` Maximum distance (meters) traveled while on track to be mergeable. Set to Inf to not consider.

Value
Modifies events data.table by reference
radiusOfGyrationDT

Description

Calculates the time-weighted radius of Gyration provided a data.table containing latitude, longitude and a timestamp. This is the root-mean-square time-weighted average of all locations. Weighting by time is provided to adjust for unequal frequency of data collection.

Usage

radiusOfGyrationDT(lat_col, lon_col, timestamp, dist_measure = "geodesic")

Arguments

- lat_col: Time-ordered vector of latitudes
- lon_col: Time-ordered vector of longitudes
- timestamp: Timestamps associated with the latitude/longitude pairs
- dist_measure: Passed through to geodist::geodist_vec, One of "haversine" "vincenty", "geodesic", or "cheap" specifying desired method of geodesic distance calculation.

Details

Time-weighted RoG is defined as

\[
\sqrt{\frac{\sum_i w_j \times dist([lon, lat], [lon_j, lat_j])}{\sum_i w_j}}
\]

Where

\[
\bar{lon} = \frac{\sum_j w_j lon_j}{\sum_j w_j} \quad \text{and} \quad \bar{lat} = \frac{\sum_j w_j lat_j}{\sum_j w_j}
\]

And the weighting element \(w_j\) represents half the time interval during which a location was recorded

\[
w_j = \frac{t_{j+1} - t_{j-1}}{2}
\]

Value

Time-weighted radius of gyration

Examples

# Inside a data.table
dt <- data.table::data.table(
  lat = c(1, 1, 1, 1, 1),
  lon = c(1, 1.5, 4, 1.5, 2),
  timestamp = c(100, 200, 300, 600, 900))
returnStateEvents

Description

Given a data.table updated with stop and move events from stopFinder, returns data aggregated to the event level.

Usage

returnStateEvents(dt)

Arguments

dt     data.table updated with stop and move events from stopFinder

Value

data.table with one line per stop/move event, annotated with columns state_id, state, begin_time, end_time and n_locations. Move events contain information on the raw_travel_dist and a move_id. Stop events have values for columns meanlat and meanlon, which are respectively the mean latitude and longitude of locations occurring during the stop.

Examples

library(data.table)
data(loc_data_2019); setDT(loc_data_2019)
stopFinder(loc_data_2019, thetaD = 200, thetaT = 300)
returnStateEvents(loc_data_2019)
stopFinder

Find an initial set of stops given timestamped locations

Description

stopFinder modifies by reference a data.table of trajectories, which are clustered spatiotemporally based on a user-provided distance radius parameter and time parameter. Points are evaluated sequentially to determine whether they meet the criteria for being a stop (at least thetaT time spent within thetaD distance of the initiating location). Points must therefore have a timestamp, longitude and latitude column.

Usage

stopFinder(traj, thetaD, thetaT)

Arguments

traj An ordered data.table with columns named timestamp, longitude and latitude
thetaD The distance parameter, represents a radius in meters for establishing how much area a stop can encompass.
thetaT The time parameter, representing the length of time that must be spent within the stop area before being considered a stop.

Details

This function has been optimized for simulation studies where it will be called repeatedly. Because of this, all error-handling is done prior to this step. If calling this function directly, the user must ensure that the data are ordered based on the timestamp, and that the columns names are correct.

Value

traj is modified by reference to include a column stop_initiation_idx, which is NA for locations not belonging to a stop, and equal to the row number initiating the stop it belongs to otherwise.

Examples

# Set up data
library(data.table)
dt <- data.table(entity_id = rep(1, 27),
timestamp = c(1, 2, 4, 10, 14, 18, 20, 21, 24, 25, 28, 29, 45, 80, 100,
120, 200, 270, 300, 340, 380, 450, 455, 460, 470, 475,
490),
longitude = c(5.1299311, 5.129979, 5.129597, 5.130028, 5.130555, 5.131083,
5.131201, 5.132704, 5.133236, 5.133904, 5.134746, 5.135613,
5.135613, 5.135613, 5.135613, 5.135613, 5.135613, 5.135613,
5.135613, 5.135613, 5.135613, 5.135613, 5.134746, 5.133904,
5.133326, 5.132704, 5.132101),
latitude = c(52.092839, 52.092827, 52.092571, 52.092292, 52.092076, 52.092292,
stopMerger

Stop Merger

Description
Given the events data.table containing the spatiotemporally clustered stop/ move states, merges stops separated by less than thetaD meters. Modifies events by reference.

Usage
stopMerger(events, thetaD)

Arguments
- **events**: data.table of events from `returnStateEvents`
- **thetaD**: maximum distance for merging subsequent stops

Value
modifies events data.table by reference, changing new_stop_id and new_state
Index

* datasets
  loc_data_2019, 2

loc_data_2019, 2
mergingCycle, 3
moveMerger, 4
radiusOfGyrationDT, 5
returnStateEvents, 4, 6, 8
stopFinder, 3, 6, 7
stopMerger, 8