Package 'trajr'

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Type Package

Title Animal Trajectory Analysis

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Description A toolbox to assist with statistical analysis of 2-dimensional animal trajectories. It provides simple access to algorithms for calculating and assessing a variety of characteristics such as speed and acceleration, as well as multiple measures of straightness or tortuosity. McLean & Skowron Volponi (2018) <doi:10.1111/eth.12739>.

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URL https://github.com/JimMcL/trajr

BugReports https://github.com/JimMcL/trajr/issues

Encoding UTF-8

LazyData true

Imports signal, utils, stats, graphics, plotrix, grDevices

RoxygenNote 6.1.1

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VignetteBuilder knitr

BuildVignettes true

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R topics documented:

```
ElapsedTimeProgressBarFn
```
A general purpose progress bar that reports elapsed time rather than number of items

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Description

A general purpose progress bar that reports elapsed time rather than number of items

Usage

```
ElapsedTimeProgressBarFn(numItems, reportFn)
```

Arguments

numItems	Number of items to be processed
reportFn	A function used to report changing progress

Value

A function which should be called for each item as it is processed.

```
lines.Trajectory
```
Add Trajectory lines to a plot

Description

The lines method for Trajectory objects.

Usage

```
## S3 method for class 'Trajectory'
lines(x, draw.start.pt = TRUE, start.pt.cex = 0.8,
  start.pt.pch = 16, start.pt.col = "black", turning.angles = NULL,
  ...)
```

Arguments

x	An object of class "Trajectory", the trajectory to be plotted.
draw.start.pt	If TRUE, draws a dot at the start point of the trajectory.
start.pt.cex	Scale to apply when drawing the start point dot.
start.pt.pch	Pch (i.e. plot character, symbol or shape) to apply when drawing the start point dot.
start.pt.col	Colour to apply when drawing the start point dot.

turning.angles   If random or directed, draws step turning angles. directed assumes errors
                 are relative to the first recorded step angle. random assumes errors are relative
                 to the previous step.

...   Additional arguments are passed to [lines](#).

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plot.TrajDirectionAutocorrelations
                          Plot method for direction autocorrelation

---

Description

The plot method for TrajDirectionAutocorrelations objects. Plots the direction autocorrelation function as returned by a call to link{TrajDirectionAutocorrelations}, with a optional dot at the first local minimum.

Usage

```
## S3 method for class 'TrajDirectionAutocorrelations'
plot(x, firstMinWindowSize = 10,
  type = "l", ylab = expression("C(" * Delta * s * ")"),
  xlab = expression(Delta * s), ...)
```

Arguments

x   Trajectory to be plotted.

firstMinWindowSize
                   If not NULL, specifies a window size used to calculate the first local minimum,
                   which is then plotted as a point.

type, xlab, ylab
                   Defaults for plotting.

...   Additional arguments passed to [plot](#).

---

plot.Trajectory   *Plot method for trajectories*

Description

The plot method for Trajectory objects.

Usage

```
## S3 method for class 'Trajectory'
plot(x, add = FALSE, draw.start.pt = TRUE,
  start.pt.cex = 0.8, start.pt.pch = 16, start.pt.col = "black",
  turning.angles = NULL, xlim = grDevices::extendrange(x$x),
  ylim = grDevices::extendrange(x$y),
  xlab = ifelse(is.null(TrajGetUnits(x)), "x", sprintf("x (%s)",
  TrajGetUnits(x))), ylab = ifelse(is.null(TrajGetUnits(x)), "y",
  sprintf("y (%s)", TrajGetUnits(x))), asp = 1, ...)
```

Arguments

x	An object of class "Trajectory", the trajectory to be plotted.
add	If TRUE, the trajectory is added to the current plot.
draw.start.pt	If TRUE, draws a dot at the start point of the trajectory.
start.pt.cex	Scale to apply when drawing the start point dot.
start.pt.pch	Pch (i.e. plot character, symbol or shape) to apply when drawing the start point dot.
start.pt.col	Colour to apply when drawing the start point dot.
turning.angles	If random or directed, draws step turning angles. directed assumes errors are relative to the first recorded step angle. random assumes errors are relative to the previous step.
xlim, ylim, xlab, ylab, asp	
	plotting parameters with useful defaults.
...	Additional arguments are passed to [plot]().

See Also

[TrajFromCoords]()

Examples

```
set.seed(42)
trj <- TrajGenerate(angularErrorSd = 1.3)
plot(trj)
```

```
plot.TrajSpeedIntervals
```
Plot method for trajectory speed intervals

Description

Plots speed over time, with intervals of fast and/or slow speed highlighted.

Usage

```
## S3 method for class 'TrajSpeedIntervals'
plot(x, slowerThanColour = "red",
  fasterThanColour = "green", highlightColor = "#0000FF1E",
  xlab = sprintf("Time (%s)", TrajGetTimeUnits(attr(x, "trajectory"))),
  ylab = sprintf("Speed (%s/%s)", TrajGetUnits(attr(x, "trajectory")),
  TrajGetTimeUnits(attr(x, "trajectory"))), ...)
```

Arguments

x   An object of class "SpeedIntervals", as created by [TrajSpeedIntervals](#).

slowerThanColour, fasterThanColour
                        The colour of the horizontal line plotted at the "slower than" or "faster than"
                        speed. Specify NULL to prevent the line from being plotted.

highlightColor   Colour of the highlight rectangles.

xlab, ylab   plotting parameters with useful defaults.

...   Additional arguments are passed to [plot](#).

See Also

[TrajSpeedIntervals](#)

---

  points.Trajectory   *Add Trajectory points to a plot*

Description

The points method for Trajectory objects.

Usage

```
## S3 method for class 'Trajectory'
points(x, draw.start.pt = TRUE,
  turning.angles = NULL, ...)
```

Arguments

x   An object of class "Trajectory", the trajectory to be plotted.

draw.start.pt   If TRUE, draws a dot at the start point of the trajectory.

turning.angles   If random or directed, draws step turning angles. directed assumes errors
                        are relative to the first recorded step angle. random assumes errors are relative
                        to the previous step.

...   Additional arguments are passed to [points](#).

TrajAngles   *Turning angles of a Trajectory*

Description

Calculates the step angles (in radians) of each segment, either relative to the previous segment or relative to the specified compass direction.

Usage

```
TrajAngles(trj, lag = 1, compass.direction = NULL)
```

Arguments

trj	the trajectory whose whose angles are to be calculated.
lag	Angles between every lag'th segment are calculated. Only applies to non-directed walks, i.e. compass.direction is NULL.

compass.direction

If not NULL, step angles are calculated relative to this angle (in radians), otherwise they are calculated relative to the previous step angle.

Details

Note that since turning angles are circular quantities, i.e. $360° == 0°$, it is incorrect to treat them as linear quantities. In particular, do not calculate arithmetic means or standard deviations of turning angles. See Batschelet, (1981) for a detailed explanation and techniques for dealing with circular quantities.

Value

Step angles in radians, normalised so that -pi < angle <= pi.

References

Batschelet, E. (1981). Circular statistics in biology. ACADEMIC PRESS, 111 FIFTH AVE., NEW YORK, NY 10003, 1981, 388.

See Also

TrajStepLengths, TrajMeanVectorOfTurningAngles

TrajConvertTime   *Converts a delimited time string to a numeric value*

Description

Time values may be imported in a format which is not immediately usable by 'trajr'. This function converts times that are specified as a number of delimited fields to a single numeric value. The default parameter values handle a value with 4 colon-separated values, which are hours, minutes, seconds and milliseconds, eg: "0:01:04:108" represents 1 minute, 4 seconds and 108 milliseconds, or 64.108 seconds.

Usage

```
TrajConvertTime(time, sep = ":", factors = c(60 * 60, 60, 1, 0.001))
```

Arguments

time   A character string containing the time value to be converted.

sep   Field separator.

factors   Vector of numeric factors to be applied to each field, in the order they occur within 'time'. The default assumes 4 fields containing numeric hours, minutes, seconds and milliseconds.

Details

Note that the base R strptime can be used to convert time values in more complex date/time formats, but it does not handle millisecond fields.

Value

'time' converted to a numeric value.

See Also

strptime

Examples

```
time <- c("0:00:00:029", "0:01:00:216", "0:02:01:062", "1:00:02:195", "1:06:03:949", "1:42:04:087")
seconds <- TrajConvertTime(time)
```

TrajDAMinMax *First direction autocorrelation minimum/maximum*

Description

Determines the coordinates of the first local minimum/maximum of C in the direction autocorrelation function of a trajectory as returned by [`TrajDirectionAutocorrelations`](#). The end point is excluded from consideration as a minimum, similarly the start point will not be returned as a maximum. if the trajectory does not osciallate in direction, there will not be a local minimum/maximum, and NULL is returned.

Usage

```
TrajDAFindFirstMinimum(corr, windowSize = 10)

TrajDAFindFirstMaximum(corr, windowSize = 10)
```

Arguments

corr   a TrajDirectionAutocorrelations object, i.e. the direction autocorrelation of a trajectory.

windowSize   Size of window used to define what constitutes a local mimimum/maximum.

Value

Numeric vector with 2 values, deltaS and C, or NULL if there is no local minimum/maximum.

See Also

[`TrajDirectionAutocorrelations`](#)

Examples

```
set.seed(42)
trj <- TrajGenerate(600, angularErrorSd = 1)
smoothed <- TrajSmoothSG(trj, 3, 11)

# Resample to fixed path length
resampled <- TrajRediscretize(smoothed, 1)
# Calculate direction autocorrelation for resampled trajectory
corr <- TrajDirectionAutocorrelations(resampled, 100)
# Extract first local minimum from autocorrelation
minPt <- TrajDAFindFirstMinimum(corr, 20)

# Plot the autocorrelation function
plot(corr, type ='l')
# Plot a red dot with a black outline at the first minimum
points(minPt["deltaS"], minPt["C"], pch = 16, col = "red", lwd = 2)
points(minPt["deltaS"], minPt["C"], col = "black", lwd = 2)
```

TrajDerivatives   *Calculates trajectory speed and linear acceleration*

Description

Calculates speed and linear acceleration along a trajectory over time. Noisy trajectories should be smoothed before being passed to this function, as noise is effectively amplifed when calculating speed and acceleration.

Usage

```
TrajDerivatives(trj)
```

Arguments

trj   Trajectory whose speed and linear acceleration is to be calculated.

Details

Note that it is possible to obtain the duration of each step in a trajectory as follows:

```
r <- TrajDerivatives(trj)
stepLengths <- diff(c(0, r$speedTimes))
```

.

Value

A list with components:

speed   numeric vector, speed between each pair of trajectory points, i.e. the speed of each step.

speedTimes   numeric vector, times corresponding to values in speed, i.e. the time from the start of the trajectory to the end of each step.

acceleration   numeric vector, linear acceleration between steps.

accelerationTimes

               numeric vector, time from start of trajectory to the end of the second step in each pair.

See Also

[TrajSpeedIntervals](#) for analysing intervals of low or high speed within the trajectory. [TrajSmoothSG](#) for smoothing a trajectory.

`TrajDirectionalChange`   *Directional change (DC)*

Description

Calculates the time variation of directional change (DC) of a trajectory *sensu* Kitamura & Imafuku (2015). Directional change is defined as the angular change (in degrees) between any two points in the trajectory, divided by the time difference between the two points.

Usage

```
TrajDirectionalChange(trj, nFrames = 1)
```

Arguments

trj   Track to calculate DC for.

nFrames   Frame delta to process: if 1, every frame is processed, if 2, every 2nd frame is
               processed, and so on. Default is 1.

Details

This function returns the DC for each pair of consecutive points. Kitamura & Imafuku (2015) used the mean and the standard deviation of DC for portions of trajectories as index values of nonlinearity and irregularity respectively.

Value

The directional change (DC) in degrees between every pair of consecutive points in the trajectory, i.e. the returned vector will have length (`nrow(trj) - 1`).

References

Kitamura, T., & Imafuku, M. (2015). Behavioural mimicry in flight path of Batesian intraspecific polymorphic butterfly Papilio polytes. Proceedings of the Royal Society B: Biological Sciences, 282(1809). doi:10.1098/rspb.2015.0483

Examples

```
set.seed(42)
trj <- TrajGenerate()
SD = mean(TrajDirectionalChange(trj))
SDDC = sd(TrajDirectionalChange(trj))
```

TrajDirectionAutocorrelations

Direction autocorrelation

Description

Calculates the autocorrelation of the track for Δs ranging from 1 to deltaSMax, based on Shamble et al. (2017). trj must have a constant step length (see `TrajRediscretize`) i.e. all segments in the trajectory must be the same length. deltaS is specified in number of segments. Call `TrajDAFindFirstMinimum` to locate the first local minimum which may be used to characterise directional periodicity in a trajectory (note that the first local minimum may not exist).

Usage

```
TrajDirectionAutocorrelations(trj, deltaSMax = round(nrow(trj)/4))
```

Arguments

trj   The trajectory to calculate the directional autocorrelations for.

deltaSMax   Maximum delta s to calculate, default is $1/4$ the number of segments in the
              trajectory.

Value

A data frame with class TrajDirectionAutocorrelations and 2 columns, deltaS and C. Plotting this object displays a graph of the direction autocorrelation function, optionally with the location of the first local minimum marked

References

Shamble, P. S., Hoy, R. R., Cohen, I., & Beatus, T. (2017). Walking like an ant: a quantitative and experimental approach to understanding locomotor mimicry in the jumping spider Myrmarachne formicaria. Proceedings of the Royal Society B: Biological Sciences, 284(1858). doi:10.1098/rspb.2017.0308

See Also

`TrajDAFindFirstMinimum`, `plot.TrajDirectionAutocorrelations`

TrajDistance *Trajectory distance*

Description

Calculates the distance between the start and end of a trajectory (or a portion of a trajectory). Also called the diffusion distance, net distance, displacement, or bee-line from start to finish.

Usage

```
TrajDistance(trj, startIndex = 1, endIndex = nrow(trj))
```

Arguments

trj	Trajectory whose distance is to be calculated.
startIndex	Index of the starting point.
endIndex	Index of the ending point.

Value

Numeric distance from the start to the end of the trajectory.

TrajDuration *Trajectory duration*

Description

Calculates the temporal duration of a trajectory (or a portion of a trajectory).

Usage

```
TrajDuration(trj, startIndex = 1, endIndex = nrow(trj))
```

Arguments

trj	Trajectory whose duration is to be calculated.
startIndex	Index of the starting point.
endIndex	Index of the ending point.

Value

Numeric duration of the trajectory, in time units.

See Also

TrajGetTimeUnits

TrajEmax   *Trajectory straightness index, E-max*

Description

Emax, the maximum expected displacement, is a single-valued measure of straightness defined by (Cheung, Zhang, Stricker, & Srinivasan, 2007). Emax-a is a dimensionless, scale-independent measure of the maximum possible expected displacement. Emax-b is Emax-a * mean step length, and gives the maximum possible expected displacement in spatial units. Values closer to 0 are more sinuous, while larger values (approaching infinity) are straighter.

Usage

```
TrajEmax(trj, eMaxB = FALSE, compass.direction = NULL)
```

Arguments

trj   Trajectory to be analysed.

eMaxB   If TRUE, calculates and returns Emax-b, otherwise returns Emax-a.

compass.direction

                   if not NULL, turning angles are calculated for a directed walk, assuming the specified compass direction (in radians). Otherwise, a random walk is assumed.

Value

Emax (-a or -b) for trj.

References

Cheung, A., Zhang, S., Stricker, C., & Srinivasan, M. V. (2007). Animal navigation: the difficulty of moving in a straight line. Biological Cybernetics, 97(1), 47-61. doi:10.1007/s00422-007-0158-0

TrajExpectedSquareDisplacement
                   Trajectory expected square displacement

Description

Calculates the expected square displacement for a trajectory assuming it is a correlated random walk, using the formula in Kareiva & Shigesada, (1983).

Usage

```
TrajExpectedSquareDisplacement(trj, n = nrow(trj), eqn1 = TRUE,
  compass.direction = NULL)
```

Arguments

`trj`	A Trajectory.
`n`	Number of steps to calculate.
`eqn1`	If `TRUE`, calculate using equation 1, otherwise using equation 2. Equation 2 applies when the mean of turning angles is 0, i.e.turns are unbiased.
`compass.direction`	
	If not `NULL`, step angles are calculated relative to this angle (in radians), otherwise they are calculated relative to the previous step angle.

Details

Note that Cheung, Zhang, Stricker, and Srinivasan (2007) define an alternative formulation for expected maximum displacement, Emax (see `TrajEmax`).

References

Cheung, A., Zhang, S., Stricker, C., & Srinivasan, M. V. (2007). Animal navigation: the difficulty of moving in a straight line. Biological Cybernetics, 97(1), 47-61. doi:10.1007/s00422-007-0158-0

Kareiva, P. M., & Shigesada, N. (1983). Analyzing insect movement as a correlated random walk. Oecologia, 56(2), 234-238. doi:10.1007/bf00379695

See Also

`TrajEmax`

Examples

```
set.seed(1)
# A random walk
trj <- TrajGenerate(200)
smoothed <- TrajSmoothSG(trj)

# Calculate actual squared displacement at all points along the trajectory
sd2 <- sapply(2:nrow(smoothed), function(n) TrajDistance(smoothed, 1, n) ^ 2)
# Calculate expected squared displacement
ed2_1 <- sapply(2:nrow(smoothed), function(n) TrajExpectedSquareDisplacement(smoothed, n, TRUE))
ed2_2 <- sapply(2:nrow(smoothed), function(n) TrajExpectedSquareDisplacement(smoothed, n, FALSE))

# Plot expected against actual. According to Kareiva & Shigesada, (1983), if actual
# (approximately) matches expected, the trajectory is probably a correlated random walk
par(mar = c(5, 5, 0.1, 0.1) + .1)
plot(2:nrow(smoothed), sd2, type = 'l', pch = 16, cex = .2, lwd = 2,
     xlab = 'Number of consecutive moves',
     ylab = expression('Squared displacement, ' * R[n]^2))
lines(2:nrow(smoothed), ed2_1, col = "grey", lwd = 2)
lines(2:nrow(smoothed), ed2_2, col = "pink", lwd = 2)

legend("bottomright",
       c(expression("Actual displacement"^2),
         expression("Expected displacement"^2 * " (eqn 1)"),
```

```
        expression("Expected displacement"^2 * " (eqn 2)")),
    col = c('black', 'grey', 'pink'), lwd = 2,
    inset = c(0.01, 0.02))
```

TrajFractalDimension   *Fractal dimension of a trajectory*

Description

Calculates the fractal dimension (D) of a trajectory using the 'dividers' method (Sugihara & May, 1990). By default, overestimation of D is compensated for as recommended by Nams (2006), by walking the dividers backwards and forwards, and by estimating the remaining path length at the end of the last step.

Usage

```
TrajFractalDimension(trj, stepSizes, adjustD = TRUE, dMean = TRUE)
```

Arguments

trj	Trajectory to calculate fractal dimension for.
stepSizes	Vector of step sizes (aka divider sizes) used to calculate path lengths.
adjustD	If TRUE, path length is adjusted for truncation error (Nams, 2006).
dMean	If TRUE, the fractal dimension is calculated starting from the beginning of the trajectory, then re-calculated starting from the end and moving backwards. The value returned is the mean of the two fractal dimensions (Nams, 2006).

Details

Fractal dimension may be meaningless for animal trajectories as they may not be true fractal curves - see Benhamou (2004) and Turchin (1996), although it may be useful for studies involving differences in behaviour at different spatial scales (Nams, 2006).

You can test whether a trajectory is a fractal curve for a range of step sizes using the TrajFractalDimensionValues function. The example code in its documentation demonstrates how to plot path length for a range of step sizes. If the plotted points lie along straight line, then the trajectory is a fractal curve for that range of step sizes. However, typical trajectories result in a curve rather than a straight line.

If you decide to use fractal dimension despite the warnings of Benhamou (2004) and Turchin (1996), try to select a biologically meaningful range of step sizes (and be prepared to justify your choice). If comparing fractal dimensions across trajectories, be consistent in your choice of step sizes.

Value

The fractal dimension of the trajectory for the given step sizes.

References

Benhamou, S. (2004). How to reliably estimate the tortuosity of an animal's path. Journal of Theoretical Biology, 229(2), 209-220. doi:10.1016/j.jtbi.2004.03.016

Nams, V. O. (2006). Improving Accuracy and Precision in Estimating Fractal Dimension of Animal movement paths. Acta Biotheoretica, 54(1), 1-11. doi:10.1007/s10441-006-5954-8

Sugihara, G., & M. May, R. (1990). Applications of fractals in ecology. Trends in Ecology & Evolution, 5(3), 79-86. doi:10.1016/0169-5347(90)90235-6

Turchin, P. (1996). Fractal Analyses of Animal Movement: A Critique. Ecology, 77(7), 2086-2090. doi:10.2307/2265702

See Also

`TrajLogSequence` to create a logarithmically spaced sequence, `TrajFractalDimensionValues` for the function used internally to calculate a range of path lengths for different step sizes, `TrajEmax` and `TrajSinuosity2` for some alternate measures of trajectory tortuosity.

```
TrajFractalDimensionValues
```
                    Fractal dimension calculation

Description

Calculates path length ($L(\delta)$) for a range of step sizes (δ). For a fractal (i.e. scale independent) curve, $log(L(\delta))$ grows linearly as $log(\delta)$ grows smaller. In other words, if the points returned by this function lie on a straight line in a log-log plot, `trj` is a fractal curve.

Usage

```
TrajFractalDimensionValues(trj, stepSizes, adjustD = TRUE)
```

Arguments

`trj`	Trajectory to calculate fractal dimension for.
`stepSizes`	Vector of step sizes used to calculate path lengths.
`adjustD`	If TRUE, path length is adjusted to reduce truncation error (Nams, 2006).

Value

Data frame with columns `stepsize` (δ) and `pathlength` (($L(\delta)$).

References

Nams, V. O. (2006). Improving Accuracy and Precision in Estimating Fractal Dimension of Animal movement paths. Acta Biotheoretica, 54(1), 1-11. doi:10.1007/s10441-006-5954-8

See Also

`TrajFractalDimension` for fractal dimension calculation.

Examples

```
set.seed(42)
trj <- TrajGenerate()
muL <- mean(TrajStepLengths(trj))
# Use 20 step sizes from 1/2 mean step length to 5 * mean step length.
# For real use, biologically meaningful step sizes should be used.
stepSizes <- TrajLogSequence(0.5 * muL, 5 * muL, 20)
plot(TrajFractalDimensionValues(trj, stepSizes), log = "xy", pch = 16, cex = .5)
```

TrajFromCoords   *Create a Trajectory Object*

Description

`TrajFromCoords` creates a new trajectory object from a set of 2-dimensional cartesian coordinates, times and some metadata. The coordinates are sometimes referred to as "relocations".

Usage

```
TrajFromCoords(track, xCol = 1, yCol = 2, timeCol = NULL, fps = 50,
  spatialUnits = "m", timeUnits = "s")
```

Arguments

track	data frame containing cartesian coordinates and optionally times for the points in the trajectory.
xCol	Name or index of the x column in `track` (default 1).
yCol	Name or index of the y column in `track` (default 2).
timeCol	optional name or index of the column which contains coordinate times.
fps	Frames per second - used to calculate relative coordinate times if `track` does not contain a `time` column. Time intervals between coordinate are assumed to be constant throught the entire track.
spatialUnits	Abbreviation for the x and y units.
timeUnits	Abbreviation for the units that time is recorded in.

Details

If `timeCol` is specified, `track[,timeCol]` is expected to contain the time (in some numeric units) of each coordinate. Otherwise, times are calculated for each point as `(coord - 1) / fps` where `coord` is the index of the point; in other words, sampling at constant time intervals is assumed. Time values require conversion if they are not numeric. It may be possible to use 'strptime' for this purpose, or [`TrajConvertTime`](#) can be used to convert mutliple field time values.

`x` and `y` must be square units. Longitude and latitude are not suitable for use as x and y values, since in general, 1° lat != 1° lon. To create a trajectory from positions in latitude and longitude, it is first necessary to transform the positions to a suitable spatial projection such as UTM (possibly by using `spTransform` from the `rgdal` package).

Value

An object with class `"Trajectory"`, which is a data.frame with the following components:

x	X coordinates of trajectory points.
y	Y coordinates of trajectory points.
time	Time (in `timeUnits`) for each point. if `timeCol` is specified, values are `trj[,timeCol]`, otherwise values are calculated from `fps`.
displacementTime	
	Relative frame/observation times, with frame/observation 1 at time `0`.
polar	Coordinates represented as complex numbers, to simplify working with segment angles.
displacement	Displacement vectors (represented as complex numbers) between each pair of consecutive points.

Examples

```
coords <- data.frame(x = c(1, 1.5, 2, 2.5, 3, 4),
                     y = c(0, 0, 1, 1, 2, 1),
                     times = c(0, 1, 2, 3, 4, 5))
trj <- TrajFromCoords(coords)

par(mar = c(4, 4, 0.5, 0.5) + 0.1)
plot(trj)
```

TrajGenerate   *Generate a random trajectory*

Description

Generates a trajectory. If `random` is `TRUE`, the trajectory will be a correllated random walk/idiothetic directed walk (Kareiva & Shigesada, 1983), corresponding to an animal navigating without a compass (Cheung, Zhang, Stricker, & Srinivasan, 2008). If `random` is `FALSE`, it will be a directed walk/allothetic directed walk/oriented path, corresponding to an animal navigating with a compass (Cheung, Zhang, Stricker, & Srinivasan, 2007, 2008).

Usage

```
TrajGenerate(n = 1000, random = TRUE, stepLength = 2,
  angularErrorSd = 0.5, angularErrorDist = function(n) stats::rnorm(n,
  sd = angularErrorSd), linearErrorSd = 0.2,
  linearErrorDist = function(n) stats::rnorm(n, sd = linearErrorSd),
  fps = 50, ...)
```

Arguments

n	Number of steps in the trajectory.
random	If TRUE, a random search trajectory is returned, otherwise a directed trajectory (with direction = 0 radians) is returned.
stepLength	Mean length of each step in the trajectory, in arbitrary length units.
angularErrorSd	Standard deviation of angular errors in radians.
angularErrorDist	
	Function which accepts a single argument - the number of values to return, and generates random deviates according to some distribution. The returned values are added to the previous step angle (when random == TRUE), or to 0 (is random == FALSE) to generate the step angle for each step in the trajectory. If the mean of the returned values is not zero, the walk will be biased.
linearErrorSd	Standard deviation of linear step length errors.
linearErrorDist	
	Function which accepts a single argument - the number of values to return, and generates random deviates according to some distribution. The returned values are added to stepLength to generate the lengths of each step.
fps	Simulated frames-per-second - used to generate times for each point in the trajectory.
...	Additional arguments are passed to `TrajFromCoords`.

Details

By default, for both random and directed walks, errors are normally distributed, unbiased, and independent of each other, so are *simple directed walks* in the terminology of Cheung, Zhang, Stricker, & Srinivasan, (2008). This behaviour may be modified by specifying alternative values for the angularErrorDist and/or linearErrorDist parameters.

The initial angle (for a random walk) or the intended direction (for a directed walk) is 0 radians. To change the initial angle or intended direction, call `TrajRotate` on the new trajectory. The starting position is (0, 0). To change the starting position, call `TrajTranslate` on the new trajectory.

Value

A new Trajectory with n segments and n + 1 coordinate pairs.

References

Kareiva, P. M., & Shigesada, N. (1983). Analyzing insect movement as a correlated random walk. Oecologia, 56(2), 234-238. doi:10.1007/bf00379695

Cheung, A., Zhang, S., Stricker, C., & Srinivasan, M. V. (2007). Animal navigation: the difficulty of moving in a straight line. Biological Cybernetics, 97(1), 47-61. doi:10.1007/s00422-007-0158-0

Cheung, A., Zhang, S., Stricker, C., & Srinivasan, M. V. (2008). Animal navigation: general properties of directed walks. Biological Cybernetics, 99(3), 197-217. doi:10.1007/s00422-008-0251-z

Examples

```
# Generate a 1000 step correlated random walk
trj <- TrajGenerate()
plot(trj, main = "Correlated walk")

# Generate a 1000 step levy flight - paths lengths follow a cauchy distribution
trj <- TrajGenerate(linearErrorDist = rcauchy)
plot(trj, main = "Levy flight")

# Generate a short directed trajectory
trj <- TrajGenerate(n = 20, random = FALSE)
plot(trj, main = "Directed walk")

# Generate an uncorrelated random walk
trj <- TrajGenerate(500, angularErrorDist = function(n) runif(n, -pi, pi))
plot(trj, main = "Uncorrelated walk")

# Generate a walk directed northwards, starting from (200, 300),
# with a mean step length of 200. The initially generated trajectory
# is directed to angle 0, with starting point (0, 0)
trj <- TrajGenerate(n = 20, stepLength = 200, random = FALSE)
# Rotate 90 degrees about (0, 0) (i.e. from east to north)
trj <- TrajRotate(trj, pi / 2, relative = FALSE)
# Translate to desired starting point
trj <- TrajTranslate(trj, 200, 300)
```

TrajGetFPS   *Trajectory frames-per-second*

Description

Returns the frames-per-second recorded for this trajectory.

Usage

```
TrajGetFPS(trj)
```

Arguments

trj   Trajectory to query

TrajGetNCoords   *Trajectory number of coordinates*

Description

Returns the number of coordinates recorded for this trajectory, i.e. 1 more than the number of steps.

Usage

```
TrajGetNCoords(trj)
```

Arguments

trj   Trajectory to query

TrajGetTimeUnits   *Trajectory temporal units*

Description

Returns the temporal units specified for a scaled trajectory.

Usage

```
TrajGetTimeUnits(trj)
```

Arguments

trj   Trajectory to query

See Also

TrajFromCoords, TrajGetUnits.

TrajGetUnits *Trajectory spatial units*

Description

Returns the spatial units specified for a scaled trajectory.

Usage

```
TrajGetUnits(trj)
```

Arguments

trj   Trajectory to query

See Also

TrajScale, TrajGetTimeUnits.

TrajLength *Trajectory length*

Description

Calculates the cumulative length of a trajectory (or a portion of a trajectory), which is the total distance travelled along the trajectory.

Usage

```
TrajLength(trj, startIndex = 1, endIndex = nrow(trj))
```

Arguments

trj   Trajectory whose length is to be calculated.

startIndex   Index of the starting point.

endIndex   Index of the ending point.

Value

Numeric length of the trajectory.

See Also

TrajStepLengths

TrajLogSequence   *Logarithmically spaced sequence*

Description

Convenience function to return a sequence of points which are regularly spaced when plotted on a logarithmic axis.

Usage

```
TrajLogSequence(from, to, length.out)
```

Arguments

from   Starting value of the sequence.

to   End (maximal) value of the sequence.

length.out   Desired length of the sequence (non-negative). Rounded up if fractional.

See Also

[seq](#)

TrajMeanVectorOfTurningAngles
                        Mean vector of turning angles

Description

Returns the mean vector of the turning angles, as defined by Batschelet, (1981). A unit vector is created for each turning angle in the trajectory, and the centre-of-mass/mean vector is returned.

Usage

```
TrajMeanVectorOfTurningAngles(trj, compass.direction = NULL)
```

Arguments

trj   Trajectory object.

compass.direction

                  If not NULL, step angles are calculated relative to this angle (in radians), other-
                  wise they are calculated relative to the previous step angle.

Details

According to Batschelet (1981), r may serve as a straightness index ranging from 0 to 1, where r is the length of the mean vector of turning angles of a trajectory with constant step length. Values of r near 1 indicating straighter paths. Hence, r = Mod(TrajMeanVectorOfTurningAngles(trj)), assuming that `trj` has a constant step length (e.g. has been rediscretized).

Value

A complex number r which represents the mean vector, Mod(r) is the length of the mean vector which varies between 0 and 1, Arg(r) is the angle.

References

Batschelet, E. (1981). Circular statistics in biology. ACADEMIC PRESS, 111 FIFTH AVE., NEW YORK, NY 10003, 1981, 388.

See Also

[TrajStraightness](#), [TrajAngles](#), [TrajRediscretize](#) for resampling a trajectory to a constant step length, [TrajResampleTime](#) for resampling a trajectory to a constant step time.

TrajMeanVelocity *Trajectory mean velocity*

Description

Calculates the mean or net velocity of a trajectory (or a portion of a trajectory). Theisis the velocity from the start point to the end point, ignoring the path that was taken.

Usage

```
TrajMeanVelocity(trj, startIndex = 1, endIndex = nrow(trj))
```

Arguments

trj	Trajectory whose duration is to be calculated.
startIndex	Index of the starting point.
endIndex	Index of the ending point.

Value

Numeric duration of the trajectory, in time units.

See Also

[TrajGetTimeUnits](#)

trajr	*trajr: trajectory analysis in R*

Description

A toolkit for the statistical analysis of 2-dimensional animal trajectories.

Details

Trajr operates on trajectories which are arrays of x and y coordinates. It can be used to calculate characteristics such as velocity and acceleration, as well as various measures of straightness or tortuosity. it also provides various convenience functions to assist with operating on multiple trajectories.

Trajr does not perform object tracking from videos, it operates on existing arrays of coordinates.

Trajectory creation

Most trajr functions operate on a Trajectory object. Trajectorys are created by calling TrajFromCoords. The function TrajsBuild allows you to create multiple Trajectorys by reading their coordinates from files.

Typically, trajectories require smoothing to remove high frequency noise; see TrajSmoothSG. Some methods require trajectories which have been resampled to a constant step length (*rediscretized*); see TrajRediscretize.

You can create a random trajectory by calling TrajGenerate.

Trajectory analysis

TrajDerivatives calculates the speed and acceleration of a trajectory (see also TrajSpeedIntervals).

Multiple algorithms for assessing straightness or tortuosity are available, see TrajDirectionalChange, TrajDirectionAutocorrelations, TrajEmax, TrajFractalDimension, TrajSinuosity, and TrajStraightness.

Other functions

Other functions provide information about trajectories, such as TrajStepLengths, TrajGetNCoords, TrajGetUnits, TrajGetTimeUnits, TrajReverse, TrajDuration, TrajMeanVelocity, or allow some manipulations of trajectories, such as TrajScale, TrajReverse, TrajTranslate, and TrajRotate.

Trajr also provides the capability to plot a Trajectory and the results of some analyses.

TrajRediscretize   *Resample a trajectory to a constant step length*

Description

Constructs a new trajectory by resampling the input trajectory to a fixed step (or segment) length. Timing of frames is lost, so speed and acceleration cannot be calculated on a rediscretized trajectory.

Usage

```
TrajRediscretize(trj, R)
```

Arguments

trj   The trajectory to be resampled.

R   rediscretization step length, in the spatial units of `trj`.

Details

Based on the appendix in Bovet and Benhamou, (1988).

Value

A new trajectory with a constant segment length which follows `trj`.

References

Bovet, P., & Benhamou, S. (1988). Spatial analysis of animals' movements using a correlated random walk model. Journal of Theoretical Biology, 131(4), 419-433. doi:10.1016/S0022-5193(88)80038-9

TrajResampleTime   *Resample a trajectory to a constant time interval.*

Description

Constructs a new trajectory by resampling the input trajectory to a fixed time interval. Points are linearly interpolated along the trajectory. Spatial and time units are preserved.

Usage

```
TrajResampleTime(trj, stepTime, newFps = NULL)
```

Arguments

`trj`	The trajectory to be resampled.
`stepTime`	The resampled trajectory step time. Each step in the new trajectory will have this duration.
`newFps`	Value to be stored as the FPS value in the new trajectory (see `TrajGetFPS`). It is not otherwise used by this function.

Value

A new trajectory with a constant time interval for each step. Points in the new trajectory are calculated by linearly interpolating along `trj`.

Examples

```
# Simulate a trajectory with steps every 5 hours
set.seed(46)
trj <- TrajGenerate(10, stepLength = 5, fps = 1/5, timeUnits = "hours", linearErrorSd = .8)

# Resample to 1 hour steps
resampled <- TrajResampleTime(trj, 1)

par(mar = c(5, 4, .5, .5))
plot(trj, lwd = 2)
points(trj, pch = 16)
points(resampled, col = "red", draw.start.pt = FALSE)
```

`TrajReverse`	*Reverse a trajectory*

Description

Reverses the direction of a trajectory, so that the starting point becomes the last point and vice versa.

Usage

```
TrajReverse(trj)
```

Arguments

`trj`	The Trajectory to be reversed.

Value

A copy of `trj` with direction reversed.

TrajRotate   *Rotate a trajectory*

Description

Rotates a trajectory by `angle` (when `relative` is `FALSE`), or so that `angle(finish - start) == angle` (when `relative` is `TRUE`).

Usage

```
TrajRotate(trj, angle = 0, origin = c(0, 0), relative = TRUE)
```

Arguments

`trj`	The trajectory to be rotated.
`angle`	The angle in radians between the first and last points in the rotated trajectory.
`origin`	Trajectory is rotated about this point.
`relative`	If TRUE, `angle` is the angle (after rotation) from the start to the end point of the trajectory. If FALSE, the trajectory is rotated about its start point by `angle`.

Value

A new trajectory which is a rotated version of the input trajectory.

TrajsBuild   *Construct multiple trajectories*

Description

Reads multiple trajectories from files, performs some basic sanity checks on them, and optionally smooths and scales them. Attempts to collect and report errors for multiple trajectories in a single call.

Usage

```
TrajsBuild(fileNames, fps = NULL, scale = NULL, spatialUnits = NULL,
  timeUnits = NULL, csvStruct = list(x = 1, y = 2, time = NULL),
  smoothP = 3, smoothN = 41, translateToOrigin = FALSE,
  rootDir = NULL, csvReadFn = function(filename, ...)
  utils::read.csv(filename, stringsAsFactors = FALSE, ...), ...)
```

Arguments

fileNames	Vector of the names of CSV files containing trajectory coordinates. All of the files must have the same columns. All file names must be unique. If rootDir is not NULL, then the file names are treated as regular expressions.
fps	Vector of frames-per-second values corresponding to the trajectories in fileNames. If length is 1, it is repeated to length(fileNames).
scale	Vector of scale values corresponding to the trajectories in fileNames. May be specified as character expressions (e.g. "1 / 1200") rather than numeric values. If NULL, the trajectories will not be scaled. If length is 1, it is repeated to length(fileNames).
spatialUnits	Abbreviated name of spatial coordinate units after scaling, e.g. "m".
timeUnits	Abbreviated name of temporal units, e.g. "s".
csvStruct	A list which identifies the columns in each CSV file which contain x-, y-, and optionally time-values.
smoothP	Filter order to be used for Savitzky-Golay smoothing (see [TrajSmoothSG](#)). If NA, no smoothing is performed.
smoothN	Filter length to be used for Savitzky-Golay smoothing (must be odd, see [TrajSmoothSG](#)). If NA, no smoothing is performed.
translateToOrigin	
	If TRUE, each trajectory is translated so that its starting point is at (0, 0).
rootDir	Optional name of a top level directory which contains the CSV files. If rootDir is not NULL, the CSV files may be located anywhere within rootDir or its sub-directories.
csvReadFn	Function used to read the CSV files. Required to accept arguments filename, ..., and return a data frame of coordinates, or a list of multiple data frames (see [read.csv](#), [read.csv2](#)). The default function calls [read.csv](#) with argument stringsAsFactors = FALSE.
...	Additional arguments passed to csvReadFn.

Details

If rootDir is not null, it should be the name of a directory which is searched for the files in fileNames. The found files are then used as the list of files to be read in. This may be useful when the names of the files are known, but their exact location within a directory structure is not known.

For each file name in fileNames, reads the file by calling csvReadFn to obtain a set of coordinates and optionally times. A Trajectory is then constructed by passing the coordinates to [TrajFromCoords](#), passing in the appropriate fps value, and x, y and time column names/indices from csvStruct. If scale is not NULL, the trajectory is scaled by calling [TrajScale](#). If smoothP and smoothN are not NULL, the trajectory is smoothed by calling [TrajSmoothSG](#).

Value

A list of trajectories.

See Also

read.csv, TrajFromCoords, TrajScale, TrajSmoothSG, TrajTranslate

Examples

```
## Not run:
# Names of CSV files containing trajectory coordinates
fileNames <- c('xy001.csv', 'xy003.csv', 'xy004.csv')
# The files are all located somewhere under this directory
rootDir <- '.'
# Scale for these files is 1 / pixels per metre
scale <- c('1/1200', '1/1350', '1/1300')
# Files have columns y, x
csvStruct <- list(x = 2, y = 1)
# Apply default smoothing, and the files are formatted as conventional CSV,
# so there's no need to specify csvReadFn
trjs <- TrajsBuild(fileNames, fps = 50, scale = scale, units = "m",
                   csvStruct = csvStruct, rootDir = rootDir)

## End(Not run)
```

TrajScale   *Scale a trajectory*

Description

Scales the cartesian coordinates in a trajectory, for example, to convert units from pixels to metres.

Usage

```
TrajScale(trj, scale, units, yScale = scale)
```

Arguments

trj	The trajectory to be scaled.
scale	Scaling factor to be applied to the trajectory coordinates.
units	Character specifying the spatial units after scaling, e.g. "m" or "metres"
yScale	Optional scaling factor to be applied to the y-axis, which may be specified if the original coordinates are not square. Defaults to scale.

Value

new scaled trajectory.

Examples

```
set.seed(42)
trj <- TrajGenerate()
# original trajectory units are pixels, measured as having
# 47 pixels in 10 mm, so to convert to metres, scale the
# trajectory by the approriate factor, i.e. (size in metres) / (size in pixels).
scale <- .01 / 47
scaled <- TrajScale(trj, scale, "m")
```

TrajSinuosity   *Sinuosity of a trajectory*

Description

Calculates the sinuosity of a (constant step length) trajectory as defined by Bovet & Benhamou (1988), which is: $S = 1.18\sigma/\sqrt{q}$ where σ is the standard deviation of the step turning angles and q is the mean step length. A corrected sinuosity index is available as the function `TrajSinuosity2` which handles a wider range of variations in step angles.

Usage

```
TrajSinuosity(trj, compass.direction = NULL)
```

Arguments

trj   Trajectory to calculate sinuosity of.

compass.direction

                    if not `NULL`, turning angles are calculated for a directed walk, assuming the spec-
                    ified compass direction (in radians). Otherwise, a random walk is assumed.

Details

If your trajectory does not have a constant step length, it should be _rediscretized_ by calling `TrajRediscretize` before calling this function.

Value

The sinuosity of `trj`.

References

Bovet, P., & Benhamou, S. (1988). Spatial analysis of animals' movements using a correlated random walk model. Journal of Theoretical Biology, 131(4), 419-433. doi:10.1016/S0022-5193(88)80038-9

See Also

`TrajAngles` for the turning angles in a trajectory, `TrajStepLengths` for the step lengths, `TrajSinuosity2` for a corrected version of sinuosity, and `TrajRediscretize` for resampling to a constant step length.

`TrajSinuosity2`   *Sinuosity of a trajectory*

Description

Calculates the sinuosity of a (constant step length) trajectory as defined by Benhamou (2004), equation 8. This is a corrected version of the sinuosity index defined in Bovet & Benhamou (1988), which is suitable for a wider range of turning angle distributions.

Usage

```
TrajSinuosity2(trj, compass.direction = NULL)
```

Arguments

trj   A Trajectory object.

compass.direction

        if not `NULL`, turning angles are calculated for a directed walk, assuming the specified compass direction (in radians). Otherwise, a random walk is assumed.

Details

This function implements the formula

$$S = 2[p(((1+c)/(1-c)) + b^2)]^{-}0.5$$

where c is the mean cosine of turning angles, and b is the coefficient of variation of the step length.

If your trajectory does not have a constant step length, it should be _rediscretized_ by calling `TrajRediscretize` before calling this function.

References

Benhamou, S. (2004). How to reliably estimate the tortuosity of an animal's path. Journal of Theoretical Biology, 229(2), 209-220. doi:10.1016/j.jtbi.2004.03.016

See Also

`TrajSinuosity` for the uncorrected sinuosity index, and `TrajRediscretize` for resampling to a constant step length.

TrajsMergeStats   *Merge trajectory characteristics*

Description

Builds a data frame by combining rows of statistical values for multiple trajectories. The statistics
for each trajectory are defined by the caller in a user defined function - see the example for one way
to achieve this.

Usage

```
TrajsMergeStats(trjs, statsFn, progressBar = c("none", "text", "win",
  "tk"), ...)
```

Arguments

trjs   List of trajectories to be characterised.

statsFn   Function to calculate statistics of interest for a single trajectory.

progressBar   Displays an optional progressbar, which may be helpful if processing is very
                slow. The progressbar is displayed by printing to the console, by using winProgressBar
                or tkProgressBar, if progressBar is "text", "win" or "tk" respectively. The
                default is no progressbar (value "none"). The "win" progressbar is only avail-
                able on Windows.

...   Additional arguments passed to statsFn.

Note

Any NULL valued statistics are converted to NAs.

Examples

```
## Not run:

# Define a function which calculates some statistics
# of interest for a single trajectory
characteriseTrajectory <- function(trj) {
  # Measures of speed
  derivs <- TrajDerivatives(trj)
  mean_speed <- mean(derivs$speed)
  sd_speed <- sd(derivs$speed)

  # Resample to constant step length.
  # Step length must be appropriate for the trajectory
  resampled <- TrajRediscretize(trj, 2)

  # Measures of straightness
  sinuosity <- TrajSinuosity2(resampled)
  Emax <- TrajEmax(resampled)
```

```
    # Periodicity
    resampled <- TrajRediscretize(trj, .001)
    corr <- TrajDirectionAutocorrelations(resampled, round(nrow(resampled) / 4))
    first_min <- TrajDAFindFirstMinimum(corr)

    # Return a list with all of the statistics for this trajectory
    list(mean_speed = mean_speed,
         sd_speed = sd_speed,
         sinuosity = sinuosity,
         Emax = Emax,
         first_min_deltaS = first_min[1],
         first_min_C = first_min[2])
}

trjs <- TrajsBuild(filenames)
stats <- TrajsMergeStats(trjs, characteriseTrajectory)

## End(Not run)
```

TrajSmoothSG   *Smooth a trajectory using a Savitzky-Golay filter*

Description

Smooths a trajectory using a Savitzky-Golay smoothing filter.

Usage

```
TrajSmoothSG(trj, p = 3, n = p + 3 - p%%2, ...)
```

Arguments

trj	The trajectory to be smoothed.
p	polynomial order (passed to [sgolayfilt](#)).
n	Filter length (or window size), must be an odd number. Passed to [sgolayfilt](#).
...	Additional arguments are passed to [sgolayfilt](#).

Details

Consider carefully the effects of smoothing an a trajectory with temporal gaps in the data. If the smoothed trajectory is to used used to derive speed and/or acceleration, it may be advisable to fill in the gaps before smoothing, possibly by calling TrajResampleTime.

Value

A new trajectory which is a smoothed version of the input trajectory.

See Also

sgolayfilt

Examples

```
set.seed(3)
trj <- TrajGenerate(500, random = TRUE, angularErrorSd = .25)
smoothed <- TrajSmoothSG(trj, 3, 31)
plot(trj)
plot(smoothed, col = "red", add = TRUE)
```

TrajSpeedIntervals   *Calculate speed time intervals*

Description

Calculates and returns a list of time intervals during which speed is slower and/or faster than specified values.

Usage

```
TrajSpeedIntervals(trj, fasterThan = NULL, slowerThan = NULL,
  interpolateTimes = TRUE)
```

Arguments

trj   Trajectory to be analysed.

fasterThan, slowerThan

                   If not NULL, intervals will cover time periods where speed exceeds/is lower than
                   this value.

interpolateTimes

                   If TRUE, times will be linearly interpolated between frames.

Value

A data frame of class "TrajSpeedIntervals", each row is an interval, columns are:

startFrame   Indices of frames at the start of each interval.

stopFrame   Indices of frames at the end of each interval.

startTime   Time at the start of each interval.

stopTime   Time at the end of each interval

duration   Duration of each interval.

The data frame will also have non-standard attributes:

trajectory   Value of the `trj` argument.

slowerThan	Value of the `slowerThan` argument.
fasterThan	Value of the `fasterThan` argument.
derivs	Value returned by calling `TrajDerivatives(trj)`.

See Also

TrajDerivatives for calculating trajectory speed and acceleration, plot.TrajSpeedIntervals for plotting speed over time with intervals highlighted.

Examples

```
# Plot speed, highlighting intervals where speed drops below 50 units/sec
set.seed(4)
trj <- TrajGenerate(200, random = TRUE)
smoothed <- TrajSmoothSG(trj, 3, 101)
intervals <- TrajSpeedIntervals(smoothed, slowerThan = 50, fasterThan = NULL)
plot(intervals)

# Report the duration of the maximum period of low speed
cat(sprintf("Duration of the longest low-speed interval was %g secs\n", max(intervals$duration)))
```

TrajsStatsReplaceNAs   *Replace NAs in a data frame*

Description

Replaces NAs in a single column of a data frame with an imputed uninformative numeric replacement value, so that a principal component analysis can be applied without discarding data. Optionally adds a new "flag" column which contains 1 for each row which originally contained NA, otherwise 0.

Usage

```
TrajsStatsReplaceNAs(df, column, replacementValue = mean(df[, column],
  na.rm = TRUE), flagColumn = NULL)
```

Arguments

df	Data frame to be adjusted.
column	Name or index of the column to be adjusted.
replacementValue	
	Numeric value to use instead of NA.
flagColumn	If not NULL, specifies the name of a new column to be added to the data frame, with value 0 for non-NA rows, 1 for NA rows. The column is added regardless of whether there are any NAs in the data.

Value

A copy of df with NAs replaced in column.

See Also

prcomp

Examples

```
df <- data.frame(x = c(1, 2, 3), y = c(NA, 5, 6), z = c(NA, NA, 9))
# Eliminate NAs in y, add a flag column, ignore other NAs
df <- TrajsStatsReplaceNAs(df, "y", flagColumn = "y.was.NA")
print(df)
```

TrajsStepLengths   *Step lengths of multiple trajectories*

Description

Returns the lengths of all of the steps in a list of trajectories

Usage

```
TrajsStepLengths(trjs)
```

Arguments

trjs   A list of Trajectory objects.

Value

A numeric vector containing the lengths of every step in every trajectory.

Examples

```
## Not run:
trjs <- TrajsBuild(fileNames, scale = scale, units = "m")
# Print a summary about the step sizes across all trajectories
print(summary(TrajsStepLengths(trjs)))

## End(Not run)
```

TrajStepLengths   *Trajectory step lengths*

Description

Returns the lengths of each step in a trajectory.

Usage

```
TrajStepLengths(trj)
```

Arguments

trj   Trajectory to query.

See Also

TrajLength

TrajStraightness   *Straightness of a Trajectory*

Description

Calculates the straightness index of a trajectory, D/L, where D is the beeline distance between the first and last points in the trajectory,and L is the path length travelled (Batschelet, 1981). Benhamou (2004) considers the straightness index to be a reliable measure of the efficiency of a directed walk, but inapplicable to random trajectories. The straightness index of a random walk tends towards zero as the number of steps increases, hence should only be used to compare the tortuosity of random walks consisting of a similar number of steps.

Usage

```
TrajStraightness(trj)
```

Arguments

trj   Trajectory to calculate straightness of.

Details

The straightness index is also known as the net-to-gross displacement ratio. According to Batschelet (1981), this value (termed *d*) is an approximation of *r*, which is the length of the mean vector of turning angles of a constant step-length trajectory (see TrajMeanVectorOfTurningAngles and TrajRediscretize for creating a constant step-length trajectory).

Value

The straightness index of `trj`, which is a value between 0 (infinitely tortuous) to 1 (a straight line).

References

Batschelet, E. (1981). Circular statistics in biology. ACADEMIC PRESS, 111 FIFTH AVE., NEW YORK, NY 10003, 1981, 388.

Benhamou, S. (2004). How to reliably estimate the tortuosity of an animal's path. Journal of Theoretical Biology, 229(2), 209-220. doi:10.1016/j.jtbi.2004.03.016

See Also

`TrajDistance` for trajectory distance (or displacement), and `TrajLength` for trajectory path length.

TrajTranslate	*Translate a trajectory*

Description

Shifts an entire trajectory by the specified delta x and y.

Usage

```
TrajTranslate(trj, dx, dy, dt = 0)
```

Arguments

trj	The Trajectory to be translated.
dx	Delta x.
dy	Delta y.
dt	Delta time.

Value

A new trajectory which is a translated version of the input trajectory.

Examples

```
# Shift a trajectory so that its origin is (10, 15).
# Note that trajectories created by TrajGenerate always start at (0, 0)
set.seed(42)
trj <- TrajGenerate()
trj <- TrajTranslate(trj, 10, 15)

# Translate a trajectory so its origin (0, 0) and it starts at time 0
trj <- TrajTranslate(trj, -trj$x[1], -trj$y[1], -trj$time[1])
```

Index