Package ‘trajr’

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ElapsedTimeProgressBarFn

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**

```r
## 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,
  ...
)
```
plot.TrajDirectionAutocorrelations

Description

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

Usage

```r
## 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 \texttt{plot}. 

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.ptpch`: 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 \texttt{lines}. 

---

plot.TrajDirectionAutocorrelations

\textit{Plot method for direction autocorrelation}
Description

The plot method for Trajectory objects.

Usage

```r
## 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

```r
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

```r
## S3 method for class 'TrajSpeedIntervals'
plot(
  x,
  slowerThanColour = "red",
  fasterThanColour = "green",
  highlightColor = 
```
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`.

TrajAcceleration

Approximates the acceleration of a trajectory

Description

Returns an approximation of the acceleration of a trajectory at each point using the second-order central finite differences.

Usage

TrajAcceleration(trj)

Arguments

- **trj**: Trajectory whose acceleration is to be calculated.

Details

'trajr' trajectories, which consist of straight line displacements between sampled locations, do not contain enough information to correctly derive velocity or acceleration. Since we have to assume a constant velocity at each step, the first derivative is discontinuous. Acceleration, therefore, is zero during each step and infinite at each change of velocity. The approximation implemented by this function assumes that acceleration occurs over a period of time: half the duration of the previous step plus half the duration of the next step.
TrajAngles

Value

Vector of complex numbers. The modulus (Mod(a)) is the magnitude of the acceleration at each point, and the argument (Arg(a)) is the direction of the acceleration. The vector has an attribute, trj, with the trajectory as its value. The first and last values will always be NA, since acceleration cannot be estimated for those points.

See Also

TrajVelocity for calculating velocity, TrajResampleTime and TrajRediscretize to resample a trajectory to fixed time or length steps.

Examples

```r
# A function to plot acceleration as arrows (scaled in length)
AccArrows <- function(acc, scale = .001, trj = attr(acc, "trj"), ...) {
  graphics::arrows(trj$x, trj$y, trj$x + Re(acc) * scale, trj$y + Im(acc) * scale, ...)
}

# Generate and plot a random trajectory
set.seed(101)
trj <- TrajGenerate(30)
plot(trj)

# Calculate acceleration
acc <- TrajAcceleration(trj)
# Plot acceleration as red arrows at each point. They need to be scaled down to
# fit in the plot, and the arrowhead lengths need to be shortened to look good
AccArrows(acc, scale = .001, col = "red", length = .1)
```

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

```r
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.
TrajConvertTime

Details

Note that since turning angles are circular quantities, i.e. $360^\circ = 0^\circ$, 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 $-\pi < \text{angle} \leq \pi$.

References


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)
```

Description
Determines the coordinates of the first local minimum/maximum of \( C \) in the direction autocorrelation function of a trajectory as returned by \texttt{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 oscillate in direction, there will not be a local minimum/maximum, and \texttt{NULL} is returned.

Usage
```
TrajDAFindFirstMinimum(corr, windowSize = 10)
TrajDAFindFirstMaximum(corr, windowSize = 10)
```

Arguments
```
corr A \texttt{TrajDirectionAutocorrelations} object, i.e. the direction autocorrelation of a trajectory.
windowSize Size of window used to define what constitutes a local minimum/maximum.
```

Value
Numeric vector with 2 values, \( \Delta S \) and \( C \), or \texttt{NULL} if there is no local minimum/maximum.

See Also
\texttt{TrajDirectionAutocorrelations}
Examples

```r
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 change of speed

Description

Calculates speed and change of speed along a trajectory over time. These are the first and second order derivatives of distance travelled over time. Noisy trajectories should be smoothed before being passed to this function, as noise is effectively amplified when taking derivatives.

Usage

```r
TrajDerivatives(trj)
```

Arguments

- `trj` Trajectory whose speed and change in speed is to be calculated.

Details

The value returned as acceleration is not technically acceleration. In mechanics, acceleration is a vector. This value is a scalar quantity: change of speed, which is sometimes known informally as acceleration. This value corresponds to the acceleration in a 1-dimensional trajectory, with the sign indicating the direction of acceleration relative to the current direction of velocity. See TrajAcceleration for an approximation of (vector) acceleration, and TrajVelocity for an approximation of velocity.
**TrajDirectionalChange**

**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, change in speed between steps. Despite the name, this is not acceleration as defined by mechanics.
- **accelerationTimes**: numeric vector, time from the start of the 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.
- **TrajAcceleration** for calculating acceleration, and **TrajVelocity** for calculating velocity.

**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


Examples

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

TrajDirectionAutocorrelations

**Description**

Calculates the autocorrelation of the track for $\Delta s$ ranging from 1 to $\delta S_{\text{Max}}$, based on Shamble et al. (2017). $\text{trj}$ must have a constant step length (see TrajRediscretize) i.e. all segments in the trajectory must be the same length. $\delta S$ 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**

```r
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, $\delta S$ and $C$. Plotting this object displays a graph of the direction autocorrelation function, optionally with the location of the first local minimum marked.

**References**

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**

```r
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**

```r
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.
**TrajEmax**

**See Also**

*TrajGetTimeUnits*

---

**TrajEmax**  
*Trajectory straightness index, E-max*

---

**Description**

$E_{max}$, the maximum expected displacement, is a single-valued measure of straightness defined by (Cheung, Zhang, Stricker, & Srinivasan, 2007). $E_{max}$-a is a dimensionless, scale-independent measure of the maximum possible expected displacement. $E_{max}$-b is $E_{max}$-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**

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

**Arguments**

- **trj**: Trajectory to be analysed.
- **eMaxB**: If TRUE, calculates and returns $E_{max}$-b, otherwise returns $E_{max}$-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**

$E_{max}$ (-a or -b) for trj.

**References**

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

```r
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


See Also

`TrajEmax`
Examples

```r
set.seed(1)
# A random walk
trj <- TrajGenerate(200)
smoothed <- TrajSmooth5G(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

```r
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


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 ($\delta$). 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(δ)))`.

**References**


**See Also**

- `TrajFractalDimension` for fractal dimension calculation.

**Examples**

```r
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 throughout 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 multiple 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 track[,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 vectors (represented as complex numbers) between each pair of consecutive points.

Examples

```r
cords <- 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(cords)
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 correlated 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

```r
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


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

Description

Returns the temporal units specified for a scaled trajectory.

Usage

TrajGetTimeUnits(trj)

Arguments

trj  Trajectory to query

See Also

TrajFromCoords, TrajGetUnits.

Description

Returns the spatial units specified for a scaled trajectory.

Usage

TrajGetUnits(trj)

Arguments

trj  Trajectory to query

See Also

TrajScale, TrajGetTimeUnits.
TrajInPolygon

Test whether each of the points in a trajectory lie inside a polygon

Description
Simply a wrapper around `point.in.polygon`. The `sp` package must be installed for this function to be called. `sp` is not automatically installed as a dependency of `trajr`.

Usage

```r
TrajInPolygon(trj, boundary)
```

Arguments

- **trj**  
  Trajectory to test
- **boundary**  
  A polygon defining the region to be tested against. Can be any structure that `xy.coords` can handle, such as a data frame with `x` and `y` columns.

Value

Integer array with a value for each point in the trajectory. Values are: 0: point is strictly exterior to boundary; 1: point is strictly interior to boundary; 2: point lies on the relative interior of an edge of boundary; 3: point is a vertex of boundary.

See Also

`point.in.polygon`, `xy.coords`

Examples

```r
# Square arena
boundary <- data.frame(x = c(-10, 10, 10, -10), y = c(-10, -10, 10, 10))

# Generate a random trajectory
set.seed(1)
trj <- TrajGenerate(n = 10, stepLength = 2, angularErrorSd = .15)

# Test which points lie inside the boundary
print(TrajInPolygon(trj, boundary))
```

```r
## [1] 1 1 1 1 1 1 0 0 0 0
```
TrajLogSequence

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

### Usage
\[ \text{TrajLength}(\text{trj}, \text{startIndex} = 1, \text{endIndex} = \text{nrow}(\text{trj})) \]

### 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
\[ \text{TrajLogSequence}(\text{from}, \text{to}, \text{length.out}) \]

### 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), otherwise 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, $r = \text{Mod}(\text{TrajMeanVectorOfTurningAngles}(\text{trj}))$, assuming that \text{trj} has a constant step length (e.g. has been rediscretized).

**Value**

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

**References**


**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). This is 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`

---

**TrajMerge**  
*Combine multiple trajectories into a single whole trajectory*

**Description**
This is the inverse of `TrajSplit`.

**Usage**
```
TrajMerge(parts)
```

**Arguments**
- `parts`  
  A list containing one or more trajectories. The trajectories are concatenated together in order.

**Value**
A single trajectory.
See Also

TrajSplit

Examples

```r
trj <- TrajGenerate(n = 20)
ntrj <- TrajMerge(TrajSplit(trj, c(3, 9, 20)))
print(all(trj == ntrj))
## [1] TRUE
```

---

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. Trajectories are created by calling `TrajFromCoords`. The function `TrajsBuild` allows you to create multiple Trajectories 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 `TrajStep_lengths`, `TrajGetN_coords`, `TrajGetUnits`, `TrajGetTimeUnits`, `TrajReverse`, `TrajDuration`, `TrajMeanVelocity`, or allow some manipulations of trajectories, such as `TrajScale`, `TrajReverse`, `TrajTranslate`, and `TrajRotate`. `TrajRedisc` also provides the capability to plot a Trajectory and the results of some analyses.

---

**TrajRedisc**  
*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**

`TrajRedisc(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**

**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

```r
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

```r
# Simulate a trajectory with steps every 5 hours
dset.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**

```r
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
```r
# 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)
```
TrajScale

## 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 appropriate factor, i.e. (size in metres) / (size in pixels).
scale <- .01 / 47
scaled <- TrajScale(trj, scale, "m")
```
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 \( \sigma \) 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 specified 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


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

Description

Calculates the sinuosity of a 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, and does not require a constant step length.

Usage

```r
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.

References


See Also

`TrajSinuosity` for the uncorrected sinuosity index.
**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**

```r
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 available on Windows.
- **...** Additional arguments passed to `statsFn`.

**Note**

Any NULL valued statistics are converted to NAs.

**Examples**

```r
## 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 <- TrajBuild(filenames)
stats <- TrajMergeStats(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`.

**Details**

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

Value

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

See Also

golayfilt

Examples

```r
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. Speed is calculated by taking the modulus of velocity (*TrajVelocity*).

#### Usage

```r
TrajSpeedIntervals(
  trj,
  fasterThan = NULL,
  slowerThan = NULL,
  interpolateTimes = TRUE,
  diff = c("backward", "central", "forward")
)
```

#### 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.
- `diff`: Method used to calculate speed, see *TrajVelocity* for details. The default is "backward" to maintain backwards compatibility; in general, "central" provides a more accurate estimate of velocity.
**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 since start of trajectory at the start of each interval.
- `stopTime`: Time since start of trajectory 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.
- `speed`: Data frame with columns `speed` and `time`.
- `derivs`: Value returned by calling `TrajDerivatives(trj)`. Provided for backwards-compatibility; use of `speed` is now preferred.

**See Also**

- `TrajVelocity` for calculating trajectory velocity, `plot.TrajSpeedIntervals` for plotting speed over time with intervals highlighted.

**Examples**

```r
# 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, diff = "central", slowerThan = 50, fasterThan = NULL)
plot(intervals)

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

---

**TrajSplit**  
*Split a trajectory into multiple sections*

**Description**

Every point in `trj` will belong to exactly one of the returned sections. Note that this function will happily create single point trajectories.

**Usage**

`TrajSplit(trj, idx)`
Arguments

trj    The trajectory to be split
idx    Indices of splits. Each new section starts at one of these indices.

Value

A list containing one or more trajectories. The first trajectory in the list contains the first points from trj. Remaining trajectories contain the points starting from each of the idx values, in ascending order.

See Also

TrajMerge, TrajSplitAtFirstCrossing

---

TrajSplitAtFirstCrossing

Split a trajectory into two parts, separated at the first boundary crossing

Description

This is basically a wrapper around TrajInPolygon and TrajSplit.

Usage

TrajSplitAtFirstCrossing(trj, boundary)

Arguments

trj    The trajectory to split.
boundary A polygon defining the boundary. Can be any structure that xy.coords can handle, such as a data frame with x and y columns.

Value

A list with 1 or 2 elements. If trj lies entirely inside or outside boundary, then the list simply contains trj. If trj crosses the boundary, then the list contains 2 trajectories. The first is the longest part of trj that lies entirely inside or outside boundary, and the second is the remainder of trj.

See Also

TrajInPolygon, TrajSplit
# Square arena
boundary <- data.frame(x = c(-10, 10, 10, -10), y = c(-10, -10, 10, 10))

# Generate a random trajectory
set.seed(1)
trj <- TrajGenerate(n = 8, stepLength = 3, angularErrorSd = .4)

# Split the trajectory where it crosses the boundary
l <- TrajSplitAtFirstCrossing(trj, boundary)

# Plot the boundary and the two trajectories
plot(NULL, xlim = range(c(boundary$x, trj$x)), ylim = range(c(boundary$y, trj$y)), asp = 1)
polygon(boundary, border = "brown", lwd = 2)
lines(l[[1]], col = "#2040ff80", lwd = 3)
lines(l[[2]], col = "#ff204080", lwd = 3)

---

**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

```r
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

Description

Returns the lengths of each step in a trajectory.

Usage

TrajStepLengths(trj)

Arguments

trj Trajectory to query.

See Also

TrajLength

TrajStraightness

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 \textit{trj}, which is a value between 0 (infinitely tortuous) to 1 (a straight line).

References


See Also

\textit{TrajDistance} for trajectory distance (or displacement), and \textit{TrajLength} for trajectory path length.

| TrajTranslate              | Translate a trajectory |

Description

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

Usage

\texttt{TrajTranslate(trj, dx, dy, dt = 0)}

Arguments

- \texttt{trj} The Trajectory to be translated.
- \texttt{dx} Delta x.
- \texttt{dy} Delta y.
- \texttt{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])
### Description

The velocity is approximated at each point of the trajectory using first-order finite differences. Central, forward or backward differences can be used. Central differences yield a more accurate approximation if the velocity is smooth. As a practical guide, if velocity doesn't change much between steps, use central differences. If it changes substantially (and not just as an artifact of recording noise), then use either forward or backward differences.

### Usage

```r
TrajVelocity(trj, diff = c("central", "forward", "backward"))
```

### Arguments

- **trj**: Trajectory whose velocity is to be calculated.
- **diff**: Type of difference to be calculated, one of "central" (the default), "forward" or "backward".

### Details

Intuitively, think of the central difference velocity at a point as the mean of the velocities of the two adjacent steps. Forward difference velocity is the velocity of the step starting at the point. Backward difference is the velocity of the step ending at the point.

### Value

A vector of complex numbers representing the velocity at each point along the trajectory. The modulus (\(\text{Mod}(v)\)) is the magnitude of the velocity, i.e. the speed; the argument (\(\text{Arg}(v)\)) is the direction of the velocity; the real part (\(\text{Re}(v)\)) is velocity in the X direction; and the imaginary part (\(\text{Im}(v)\)) is velocity in the Y direction. The vector has an attribute, trj, with the trajectory as its value. If diff is "central", the first and last velocity values are NA since velocity cannot be calculated for them. If diff is "forward", the last value will be NA, and if diff is "backward", the first value will be NA.

### See Also

- `TrajAcceleration` for calculating acceleration; `TrajResampleTime` and `TrajRediscretize` to resample a trajectory to fixed time or length steps; `TrajSpeedIntervals` for calculating when speed crosses some threshold; Finite differences on `Wikipedia`. 
Examples

```r
set.seed(11)
trj <- TrajGenerate(100)
# calculate velocity
vel <- TrajVelocity(trj)

# Obtain speed over time, with NAs removed
speed <- na.omit(data.frame(speed = Mod(vel), time = trj$time))

plot(speed ~ time, speed, type = 'l')
```
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