Package 'trajectories'

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Title Classes and Methods for Trajectory Data

Depends R (>= 3.0.0)

Imports stats, utils, graphics, methods, lattice, sp (>= 1.1-0), spacetime (>= 1.0-0), zoo

Suggests rgdal, rgeos, OpenStreetMap, RCurl, rjson, adehabitatLT, xts, knitr, rgl, forecast, MASS, spatstat (>= 2.0-1), spatstat.explore, spatstat.geom, taxidata

Description Classes and methods for trajectory data, with support for nesting individual Track objects in track sets (Tracks) and track sets for different entities in collections of Tracks. Methods include selection, generalization, aggregation, intersection, simulation, and plotting.

License GPL (>= 2)

URL https://github.com/edzer/trajectories

Additional_repositories http://gis-bigdata.uni-muenster.de/pebesma/

BugReports https://github.com/edzer/trajectories/issues

VignetteBuilder knitr

Collate Class-Tracks.R Tracks-methods.R generalize.R stcube.R stplot.R difftrack.R compare-methods.R rtracks.R Trackstat.R

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NeedsCompilation no

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Repository CRAN

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R topics documented:

A3 *Trajectory*

Description

Trajectory, locally stored, from envirocar.org, see example below how it was imported

Usage

```
data(A3)
```

Examples

```
library(spacetime)
data(A3)
dim(A3)
# see demo(A3) to see how A3 was fetched, and created from the web service
```

as.list.Tracks *as.list.Tracks*

Description

Convert a "Tracks" object to a list of tracks

Usage

```
## S3 method for class 'Tracks'
as.list(x,...)
```

Arguments

x	an object of class "Tracks"
...	passed to arguments of as.list

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, rTracks, rTracksCollection, as.list

Examples

```
x <-  rTracks()
as.list(x)
```

as.list.TracksCollection *as.list.TracksCollection*

Description

Convert a "TracksCollection" object to a list of tracks

Usage

```
## S3 method for class 'TracksCollection'
as.list(x,...)
```

Arguments

x	an object of class "TracksCollection"
...	passed to arguments of as.list

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, rTracks, rTracksCollection, as.list

Examples

```
x <-  rTracksCollection()
as.list(x)
```

as.Track *Converts data to an object of class "Track"*

Description

Function as.Track accepts converts x,y coordinates and thier corresponding time/date to an object of class Track. It can also accepts covariates for the corresponding locations, covariates must be a dataframe with some columns and length of each column is equal to length of x,y,t.

Usage

```
as.Track(x,y,t,covariate)
```

Arguments

x	x coordinate.
y	y coordinate.
t	corresponding time and date of x,y.
covariate	additional information.

Details

An object of class "Track" can be created by some geographical locations and corresponding time/dates. Function as.Track converts locations and dates/times to an object of class "Track". time/date should be from class "POSIXct" "POSIXt". See example below.

Value

An object of class "Track".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

Track, as.POSIXct

Examples

```
x <- runif(10,0,1)
y <- runif(10,0,1)
date <- seq(as.POSIXct("2015-1-1 0:00"), as.POSIXct("2015-1-1 9:00"), by = "hour")
Z <- as.Track(x,y,date)
plot(Z)
```

---

as.Track.arrow *Convert trajectory pattern to a list of marked point patterns*

Description

Converting a list of Track objects to a list of marked point patterns. Each mark shows the length of movement.

Usage

```
as.Track.arrow(X,timestamp,epsilon=epsilon)
```

Arguments

X	A list of Track objects
timestamp	based on secs, mins,...
epsilon	(optional) movements with length less than epsilon are not considered in the calculation

Details

Converting a list of Track objetcs to a list of marked point patterns. Marks show the length of movement with respect to the previous location.

Value

a list of marked point patterns.

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, as.Track.ppp

Examples

```
X <- list()
for(i in 1:10){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}
Y <- as.Track.arrow(X,timestamp="120 secs")
```

---

as.Track.ppp *Conver trajectory pattern to a list of objects of class ppp*

Description

This function converts a list of Tracks to a list of point patterns (class "ppp")

Usage

```
as.Track.ppp(X,timestamp)
```

Arguments

X	a list of Track objects
timestamp	based on secs, mins,...

Details

as.Track.ppp converts a list of Track objetcs to a list of ppp objetcs.

Value

A list of point patterns, objects of class "ppp".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

avedistTrack, as.ppp

Examples

```
X <- list()
for(i in 1:10){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}
Y <- as.Track.ppp(X,timestamp="120 secs")
```

---

auto.arima.Track *Fitting arima model to a track*

Description

Fit arima models to objects of class "Track".

Usage

```
auto.arima.Track(X, ...)
```

Arguments

X	an object of class "Track"
...	passed to arguments of auto.arima

Details

This fita arima models to the x,y locations of objects of class "Track".

Value

an object of class "ArimaTrack"

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, auto.arima

Examples

```
X <- rTrack()
auto.arima.Track(X)
```

`avedistTrack` *Average pairwise distance of trajectory pattern over time*

Description

This measures the average of pairwise distances between tracks over time.

Usage

```
avedistTrack(X,timestamp)
```

Arguments

`X`	a list of some objects of class "Track"
`timestamp`	timestamp to calculate the pairwise distances between tarcks

Details

This function calculates the average pairwise distance between a list of tracks according to a given timestamp.

Value

An object of class "distrack". It can be plotted over time.

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

as.Track.ppp

Examples

```
X <- list()
for(i in 1:10){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}

ave <- avedistTrack(X,timestamp = "120 secs")
plot(ave,type="l")
```

---

avemove *Average movement of trajectory pattern*

Description

This returns the average movements of a lits of objects of class "Track" over time.

Usage

```
avemove(X,timestamp,epsilon=epsilon)
```

Arguments

X	a list of some objects of class Track
timestamp	timestamp to calculate the pairwise distances between tarcks
epsilon	(optional) movements with length less than epsilon are not considered in the calculation

Details

when analysying a list of tracks, avemove calculate the average of movements based on given timestamp.

Value

an object of class "numeric" or "arwlen".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

as.Track.arrow

Examples

```
X <- list()
for(i in 1:10){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}
avemove(X,timestamp = "30 secs")
```

---

chimaps *Chimaps of tarjectory pattern.*

Description

Computes the chimaps, corresponding to a list of objects of class "Track". chimaps are based on the discrepancy between computed and expected intensity in a given location.

Usage

```
chimaps(X,timestamp,rank,...)
```

Arguments

X	A list of Track objects
timestamp	based on secs,mins,...
rank	a number between one and the length of corresponding time sequance which is created based on given timestamp.
...	passed to arguments of density.Track

Details

[estimated intensity - expected intensity] / sqrt(expected intensity).

Value

an image of class "im".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

density.list, density.ppp

Examples

```
X <- list()
for(i in 1:10){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}
chimaps(X, timestamp = "180 secs",rank = 2)
```

---

compare *Compares objects of class* Track

Description

Calculates distances between two tracks for the overlapping time interval.

Usage

```
## S4 method for signature 'Track'
compare(tr1, tr2)
```

Arguments

tr1	An object of class Track.
tr2	An object of class Track.

Value

A difftrack object. Includes both tracks extended with additional points for the timestamps of the other track. Also includes SpatialLines representing the distances between the tracks.

Author(s)

Nikolai Gorte <n.gorte@gmail.com>

Examples

```
## example tracks
library(sp)
library(xts)
data(A3)
track2 <- A3
index(track2@time) <- index(track2@time) + 32
track2@sp@coords <- track2@sp@coords + 0.003

## compare and plot
difftrack <- compare(A3, track2)
plot(difftrack)
```

cut *obtain ranges of space and time coordinates*

Description

obtain ranges of space and time coordinates

Usage

```
## S3 method for class 'Track'
cut(x, breaks, ..., include.lowest = TRUE, touch = TRUE)
## S3 method for class 'Tracks'
cut(x, breaks, ...)
## S3 method for class 'TracksCollection'
cut(x, breaks, ...)
```

Arguments

x	object of class Track, Tracks or TracksCollection
breaks	define the breaks; see cut
...	passed down to Tracks and Track methods, then to cut
include.lowest	see cut
touch	logical; if FALSE, Track objects will be formed from unique sets of points, meaning that gaps between two consecutive Track objects will arise; if FALSE, the first point from each next track is copied, meaning that sets of Track are seamless.

Details

sub-trajectories can be invalid, if they have only one point, and are ignored. This can happen at the start only if touch=FALSE, and at the end in any case.

Value

The cut method applied to a Track object cuts the track in pieces, and hence returns a Tracks object. cut.Tracks returns a Tracks object, cut.TracksCollection returns a TracksCollection.

Examples

```
# example might take too long for CRAN checks
data(storms)
dim(storms)
dim(cut(storms, "week", touches = FALSE)) # same number of geometries
dim(cut(storms, "week")) # increase of geometries = increase of tracks
```

`density.list` *Kernel estimate of intensity of trajectory pattern*

Description

Estimating the intensity of a list of tracks.

Usage

```
## S3 method for class 'list'
density(x, timestamp,...)
```

Arguments

`x`	a list of "Track" objects, an object of class "Tracks" or "TracksCollection"
`timestamp`	based on secs, mins, ...
`...`	passed to arguments of density.ppp

Details

This estimate the average intensity function of moving objects over time. Bandwidth selection methods such as bw.diggle, bw.scott and bw.ppl can be passed to this density.list.

Value

an image of class "im".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, density.ppp

Examples

```
X <- list()
for(i in 1:10){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}
density(X, timestamp = "180 secs")
```

`difftrack-class` *Class "difftrack"*

Description

Class that represents differences between two Track objects.

Objects from the Class

Objects can be created by calls of the form `new("difftrack", ...)`. Objects of class `difftrack` contain 2 objects of class Track extended with points for timestamps of the other track and 2 SpatialLinesDataFrame conataining the the lines and distances between tracks.

Slots

`track1`: Extended track1

`track2`: Extended track2

`conns1`: Lines between the original track1 and the new points on track2

`conns2`: Lines between the original track2 and the new points on track1

Methods

plot `signature(x = "difftrack", y = "missing")`: plot a difftrack

Author(s)

Nikolai Gorte <n.gorte@gmail.com>

Examples

```
showClass("difftrack")
## example tracks
library(sp)
library(xts)
data(A3)
track2 <- A3
index(track2@time) <- index(track2@time) + 32
track2@sp@coords <- track2@sp@coords + 0.003

## compare and plot
difftrack <- compare(A3, track2)
plot(difftrack)

## space-time cube of the difftrack
## Not run:
 stcube(difftrack)

## End(Not run)
```

dists *Calculate distances between two* Tracks *objects*

Description

Calculates a distance matrix with distances for each pair of tracks.

Usage

```
## S4 method for signature 'Tracks,Tracks'
dists(tr1, tr2, f, ...)
```

Arguments

tr1	An object of class Tracks.
tr2	An object of class Tracks.
f	A function to calculate distances. Default is mean.
...	Additional parameters passed to f.

Details

f can be any function applicable to a numerical vector or frechetDist.

Value

A matrix with distances between each pair of tracks or NA if they don't overlap in time.

Examples

```
## example tracks
library(sp)
library(xts)
data(A3)
track2 <- A3
index(track2@time) <- index(track2@time) + 32
track2@sp@coords <- track2@sp@coords + 0.003

## create Tracks objects
tracks1 <- Tracks(list(A3, track2))
tracks2 <- Tracks(list(track2, A3))

## calculate distances
## Not run:
dists(tracks1, tracks2)
dists(tracks1, tracks2, sum)
dists(tracks1, tracks2, frechetDist)

## End(Not run)
```

downsample *Downsample a* Track

Description

Downsamples a Track to the size (amount of points) of another Track.

Usage

```
## S4 method for signature 'Track'
downsample(track1, track2)
```

Arguments

track1	Track that will be downsampled.
track2	Reference Track.

Value

A Track object. The downsampled track1.

Author(s)

Nikolai Gorte <n.gorte@gmail.com>

frechetDist *Frechet distance*

Description

Compute the discrete Frechet distance between two Track objects.

Usage

```
## S4 method for signature 'Track'
frechetDist(track1, track2)
```

Arguments

track1	An object of class Track.
track2	An object of class Track.

Value

Discrete Frechet distance.

Author(s)

Nikolai Gorte <n.gorte@gmail.com>

References

http://en.wikipedia.org/wiki/Fr\'echet_distance

`generalize` *Generalize objects of class* `Track`, `Tracks` *and* `TracksCollection`

Description

Generalize objects of class `Track`, `Tracks` and `TracksCollection`.

Usage

```
## S4 method for signature 'Track'
generalize(t, FUN = mean, ...,  timeInterval, distance, n, tol, toPoints)
## S4 method for signature 'Tracks'
generalize(t, FUN = mean, ...)
## S4 method for signature 'TracksCollection'
generalize(t, FUN = mean, ...)
```

Arguments

`t`	An object of class `Track`, `Tracks` or `TracksCollection`.
`FUN`	The generalization method to be applied. Defaults to `mean` if none is passed.
`timeInterval`	(lower limit) time interval to split Track into segments
`distance`	(lower limit) distance to split Track into segments
`n`	number of points to form segments
`tol`	tolerance passed on to gSimplify, to generalize segments using the Douglas-Peucker algorithm.
`toPoints`	keep mid point rather than forming SpatialLines segments
`...`	Additional arguments passed to FUN

Value

An object of class `Track`, `Tracks` or `TracksCollection`.

Kinhom.Track *Inhomogeneous K-function for trajectory pattern*

Description

Estimate the variability area of K-function of a list of tracks.

Usage

```
Kinhom.Track(X,timestamp,
               correction=c("border", "bord.modif", "isotropic", "translate"),q,
                 sigma=c("default","bw.diggle","bw.ppl"," bw.scott"),...)
```

Arguments

X	A list of Track objects
timestamp	based on secs,mins,...
correction	the type of correction to be used in computing K-function
q	(optional) a numeric value between 0 and 1. quantile to be applied to calculate the variability area
sigma	method to be used in computing intensity function
...	passed to the arguments of Kinhom

Details

This calculates the variability area of K-function over time. If sigma=default, it calculates the variability area using the defaults of Kinhom, otherwise it first estimate the intensity function using the given sigma as bandwidth selection method and then using the estimated intensity function, it estimates the variability area.

Value

an object of class "KTrack".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, as.Track.ppp, Kinhom

Examples

```
if (require(spatstat)) {
X <- list()
for(i in 1:50){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}
Kinhom.Track(X, timestamp = "180 secs")
}
```

`pcfinhom.Track` *Pair correlation funcrion of trajectory pattern*

Description

Pair correlation funcrion of trajectory pattern

Usage

```
pcfinhom.Track(X,timestamp,correction = c("translate", "Ripley"),q,
                sigma=c("default","bw.diggle","bw.ppl","bw.scott"),...)
```

Arguments

`X`	A list of Track objects
`timestamp`	based on secs,mins,...
`correction`	the type of correction to be used in computing pair correlation function
`q`	(optional) a numeric value between 0 and 1. quantile to be applied to calculate the variability area
`sigma`	method to be used in computing intensity function
`...`	passed to the arguments of pcfinhom

Details

This calculates the variability area of pair correlation function over time. If sigma=default, it calculates the variability area using the defaults of pcfinhom, otherwise it first estimate the intensity function using the given sigma as bandwidth selection method and then using the estimated intensity function, it estimates the variability area.

Value

an object of class "gTrack"

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, as.Track.ppp, pcfinhom

Examples

```
X <- list()
for(i in 1:100){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}
g <- pcfinhom.Track(X,timestamp = "180 sec")
plot(g)
```

---

plot.arwlen *Methods for class "arwlen"*

Description

Methods for class "arwlen"

Usage

```
## S3 method for class 'arwlen'
plot(x, ...)
```

Arguments

x	an object of class "arwlen"
...	passed on to plot

Value

a plot.

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

avemove

plot.distrack *Methods for class "distrack"*

Description

The plot method for "distrack" objects.

Usage

```
## S3 method for class 'distrack'
plot(x, ...)
```

Arguments

x	an object of class "distrack"
...	ignored

Details

This plots an object of class "distrack".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

plot.gTrack *Methods for class "gTrack"*

Description

plot method

Usage

```
## S3 method for class 'gTrack'
plot(x, type = "l", col = "grey70",cex=1,line=2.2, ...)
```

Arguments

x	an object of class "gTrack"
type	line type
col	line color
cex	used for size of legend
line	specifying a value for line overrides the default placement of labels, and places them this many lines outwards from the plot edge
...	passed on to plot

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

`plot.KTrack` *Methods for class "KTrack"*

Description

Methods for class "KTrack"

Usage

```
## S3 method for class 'KTrack'
plot(x, type = "l", col = "grey70",cex=1,line=2.2, ...)
```

Arguments

`x`	an object of class KTrack
`type`	line type
`col`	color
`cex`	used for size of legend
`line`	specifying a value for line overrides the default placement of labels, and places them this many lines outwards from the plot edge
`...`	passed on to plot

Details

plotting the variability area of K-function of a list of tracks.

Value

a plot.

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

print.ArimaTrack *Methods for class "ArimaTrack"*

Description

print method.

Usage

```
## S3 method for class 'ArimaTrack'
print(x, ...)
```

Arguments

x	an object of class "ArimaTrack"
...	ignored

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

print.arwlen *Methods for class "arwlen"*

Description

to print an object of class "arwlen".

Usage

```
## S3 method for class 'arwlen'
print(x,...)
```

Arguments

x	an object of class "arqlen"
...	ignored

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

print.distrack *Methods for class "distrack"*

Description

This is a method for class "distrack".

Usage

```
## S3 method for class 'distrack'
print(x,...)
```

Arguments

x	an object of class "distrack"
...	ignored

Details

This is a method for class "distrack".

Value

See the documentation on the corresponding generic function.

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

Examples

```
X <- list()
for(i in 1:10){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}

ave <- avedistTrack(X,timestamp = "30 secs")
plot(ave,type="l")
```

print.gTrack *Methods for class "gTrack"*

Description

print method.

Usage

```
## S3 method for class 'gTrack'
print(x,...)
```

Arguments

x	an object of class "gTrack"
...	ignored

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

print.KTrack *Methods for class "KTrack"*

Description

Methods for class "KTrack"

Usage

```
## S3 method for class 'KTrack'
print(x,...)
```

Arguments

x	an object of class "KTrack"
...	ignored

Details

to print an object of class "KTrack".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

print.ppplist *Methods for class "Track"*

Description

method to print an object of class "ppplist"

Usage

```
  ## S3 method for class 'ppplist'
print(x,...)
```

Arguments

x	an object of class "ppplist"
...	ignored

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

print.Track *Methods for class "Track"*

Description

method to print an object of class "Track"

Usage

```
## S3 method for class 'Track'
print(x,...)
```

Arguments

x	an object of class "Track"
...	ignored

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

print.Tracks *Methods for class "Tracks"*

Description

method to print an object of class "Tracks"

Usage

```
print.Tracks(X)
```

Arguments

X	an object of class "Tracks"

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

print.TracksCollection *Methods for class "TracksCollection"*

Description

method to print an object of class "TracksCollection"

Usage

```
print.TracksCollection(X)
```

Arguments

X	an object of class "TracksCollection"

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

print.Trrow *Methods for class "Trrow"*

Description

Print objetcs of class "Trrow"

Usage

```
## S3 method for class 'Trrow'
print(x,...)
```

Arguments

x	an object of class "Trrow"
...	ignored

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

as.Track.arrow

range.Track *range.Track*

Description

Retrieves the range of a "Track" object

Usage

```
## S3 method for class 'Track'
range(X,...)
```

Arguments

X	an object of class "Track"
...	passed to arguments of range

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, rTracks, rTracksCollection, range

Examples

```
x <-  rTrack()
range(x)
```

`reTrack` *Reconstruct objects of class "Track"*

Description

Function reTrack accepts X as an object of class "Track". Output is a reconstructed Track (again an object of class Track), based on a regular "timestamp". It only returns the interpolated points.

Usage

```
reTrack(X,at=c("track","dfrm"),timestamp=timestamp,tsq=NULL)
```

Arguments

`X`	an object of class Track
`at`	to set the type of output as either an object of class "Track" or data.frame
`timestamp`	timestamp which Track be reconstructed based on
`tsq`	a time sequence to reconstruct Track X based on it. This is optional. If this is not given, the function creates the time sequance based on timestamp.

Details

Sometimes tracks data are not collected according to a regular timestamp. In order to compare different tracks which share some time intervals, we might need to be aware of the locations in a regular timestamp. Function reTrack unables us to reconstruct an object of class "Track" based on a regular timestamp. Time sequance can be given by user, if not reTrack creates a regulare time sequance based on the given timestamp.

Value

Either an object of class "Track" or a data.frame

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, as.Track, as.POSIXct, compare

Examples

```
library(sp)
library(spacetime)
# t0 = as.POSIXct(as.Date("2013-09-30",tz="CET"))
t0 = as.POSIXct("2013-09-30 02:00:00", tz = "Europe/Berlin")

# person A, track 1:
x = c(7,6,5,5,4,3,3)
y = c(7,7,6,5,5,6,7)
n = length(x)
set.seed(131)
t = t0 + cumsum(runif(n) * 60)
require(rgdal)
crs = CRS("+proj=longlat +datum=WGS84") # longlat
stidf = STIDF(SpatialPoints(cbind(x,y),crs), t, data.frame(co2 = rnorm(n)))
A1 = Track(stidf)
reTrack(A1,timestamp = "1 sec")
```

---

rTrack *Generate random* Track, Tracks *or* TracksCollection *objects*

Description

Generate random Track, Tracks or TracksCollection objects

Usage

```
rTrack(n = 100, origin = c(0,0), start = as.POSIXct("1970-01-01"), ar = .8,
step = 60, sd0 = 1, bbox = bbox, transform = FALSE, nrandom = FALSE, ...)
rTracks(m = 20, start = as.POSIXct("1970-01-01"), delta = 7200, sd1 = 0,
origin = c(0,0), ...)
rTracksCollection(p = 10, sd2 = 0, ...)
```

Arguments

n	number of points per Track
origin	numeric, length two, indicating the origin of the Track
start	POSIXct, indicating the start time of the Track
ar	numeric vector, indicating the amound of correlation in the Track
step	numeric; time step(s) in seconds between Track fixes
sd0	standard deviation of the random steps in a Track
sd1	standard deviation of the consecutive Track origin values (using rnorm)
sd2	standard deviation of the consecutive Tracks origin values (using rnorm)
bbox	bbox object FIXME:fill in

transform	logical; FIXME:fill in
nrandom	logical; if TRUE, draw n from rpois(n)
...	rTrack: arguments passed on to arima.sim, rTracks: arguments passed on to rTrack; rTracksCollection: arguments passed on to rTracks
m	number of Track objects to simulate
delta	time difference between consecutive Track start times
p	number of IDs with Tracks to generate

Details

ar is passed on to arima.sim as ar element, and may contain multiple AR coefficients. The generated track is a cumsum over the simulated AR values, for each dimension. In case it has length 1 and value 0, random walk is created using rnorm. If bbox is given, the generated track will be transformed to bbox. If transform is TRUE and no bbox is given, it transforms the track to a unit box. If nrandom is TRUE, it generates a random number using rpois with parameter n as the number of locations per track.

Value

An object of class Track, Tracks or TracksCollection.

Author(s)

Edzer Pebesma <edzer.pebesma@uni-muenster.de>, Mohammad Mehdi Moradi <moradi@uji.es>

Examples

```
x = rTrack()
dim(x)
plot(x)
# x = rTracks(sd1 = 120)
# dim(x)
# plot(as(x, "SpatialLines"), col = 1:dim(x)[1], axes=TRUE)
# x = rTracksCollection() # star
# dim(x)
# plot(x)
x = rTracksCollection(sd2 = 200,p=4,m=10)
plot(x, col=1:dim(x)[1])
```

---

stbox *obtain ranges of space and time coordinates*

Description

obtain ranges of space and time coordinates

Usage

```
stbox(obj)
```

Arguments

obj	object of a class deriving from Tracks or TracksCollection.

Value

stbox returns a data.frame, with three columns representing x-, y- and time-coordinates, and two rows containing min and max values. bbox gives a matrix with coordinate min/max values, compatible to bbox

Methods

stbox signature(x = "Tracks"): obtain st range from object

stbox signature(x = "TracksCollection"): obtain st range from object

---

stcube *Draw a space-time cube.*

Description

Draw a space-time cube for a Track, TRacks, TracksCollection, difftrack or STI(DF) class.

Usage

```
## S4 method for signature 'Track'
stcube(x, xlab = "x", ylab = "y", zlab = "t", type = "l",
aspect, xlim = stbox(x)[[1]] + c(-0.1,0.1) * diff(stbox(x)[[1]]),
         ylim = stbox(x)[[2]] + c(-0.1,0.1) * diff(stbox(x)[[2]]),
zlim = stbox(x)$time, showMap = FALSE, mapType = "osm",
mapZoom = NULL, ..., y, z)
## S4 method for signature 'Tracks'
stcube(x, xlab = "x", ylab = "y", zlab = "t", type = "l",
aspect, xlim, ylim, zlim, showMap = FALSE, mapType = "osm",
normalizeBy = "week", mapZoom = NULL, ..., y, z, col)
## S4 method for signature 'TracksCollection'
stcube(x, xlab = "x", ylab = "y", zlab = "t",
type = "l", aspect, xlim, ylim, zlim, showMap = FALSE, mapType = "osm",
normalizeBy = "week", mapZoom = NULL, ..., y, z, col)
## S4 method for signature 'difftrack'
stcube(x, showMap = FALSE, mapType = "osm", normalizeBy = "week", ..., y, z)
## S4 method for signature 'STI'
stcube(x, xlab = "x", ylab = "y", zlab = "t", type = "p", aspect,
```

```
                        xlim = stbox(x)[[1]] + c(-0.1,0.1) * diff(stbox(x)[[1]]),
                       ylim = stbox(x)[[2]] + c(-0.1,0.1) * diff(stbox(x)[[2]]),
                       zlim = stbox(x)$time,
                      showMap = FALSE, mapType = "osm", mapZoom = NULL, ..., y, z)
## S4 method for signature 'STIDF'
stcube(x, xlab = "x", ylab = "y", zlab = "t", type = "p", aspect,
                        xlim = stbox(x)[[1]] + c(-0.1,0.1) * diff(stbox(x)[[1]]),
                       ylim = stbox(x)[[2]] + c(-0.1,0.1) * diff(stbox(x)[[2]]),
                       zlim = stbox(x)$time,
                    showMap = FALSE, mapType = "osm", mapZoom = NULL, col, ..., y, z)
```

Arguments

x	An object of class Track, Tracks, or TracksCollection or difftrack.
xlab, ylab, zlab, type, aspect, xlim, ylim, zlim	Arguments passed to plot3d() of package rgl.
showMap	Flag if a basemap is to be shown on the xy plane; for this to function, you may need to load library raster first, see also the stcube demo script.
mapType	The tile server from which to get the map. Passed as type to openmap() of package OpenStreetMap.
normalizeBy	An abstract time period (either week or day) to be normalized by.
mapZoom	Set a zoom level for the map used as background. Null will use the osm package default strategie.
y, z, col	Ignored, but included in the method signature for implementation reasons.
...	Additional arguments passed to plot3d() of package rgl.

Value

A space-time cube.

Examples

```
## Not run: demo(stcube)
```

---

storms *Storm trajectories*

Description

storm trajectories, 2009-2012, from http://weather.unisys.com/hurricane/atlantic/

Usage

```
data(storms)
```

Examples

```
data(storms)
dim(storms)
plot(storms)
x = approxTracksCollection(storms, by = "30 min", FUN = spline)
plot(x, col = 'red', add = TRUE)
## Not run:
demo(storms) # regenerates these data from their source

## End(Not run)
```

Track-class *Classes "Track", "Tracks", and "TracksCollection"*

Description

Classes for representing sets of trajectory data, with attributes, for different IDs (persons, objects, etc)

Usage

```
  Track(track, df = fn(track), fn = TrackStats)
  Tracks(tracks, tracksData = data.frame(row.names=names(tracks)),
   fn = TrackSummary)
  TracksCollection(tracksCollection, tracksCollectionData,
   fn = TracksSummary)
  TrackStats(track)
  TrackSummary(track)
  TracksSummary(tracksCollection)
  ## S4 method for signature 'Track'
x[i, j, ..., drop = TRUE]
  ## S4 method for signature 'TracksCollection'
x[i, j, ..., drop = TRUE]
  ## S4 method for signature 'Track,data.frame'
coerce(from, to)
  ## S4 method for signature 'Tracks,data.frame'
coerce(from, to)
  ## S4 method for signature 'TracksCollection,data.frame'
coerce(from, to)
```

Arguments

track	object of class STIDF-class, representing a single trip
df	optional data.frame with information between track points
tracks	named list with Track objects

tracksData	data.frame with summary data for each Track
tracksCollection	list, with Tracks objects
tracksCollectionData	data.frame, with summary data on tracksCollection
fn	function;
x	object of class Track etc
i	selection of spatial entities
j	selection of temporal entities (see syntax in package xts)
...	selection of attribute(s)
drop	logical
from	from
to	target class

Value

Functions Track, Tracks and TracksCollection are constructor functions that take the slots as arguments, check object validity, and compute summary statistics on the track and tracks sets.

TrackStats returns a data.frame with for each track segment the distance, duration, speed, and direction. In case data are geographical coordinates (long/lat), distance is in m, and direction is initial bearing.

TrackSummary reports for each track xmin, xmax, ymin, ymax, tmin, tmax, (number of points) n, (total) distance, and medspeed (median speed).

TracksSummary reports for each Tracks of a TracksCollection (number of tracks) n, xmin, xmax, ymin, ymax, tmin, tmin, tmax.

Objects from the Class

Objects of class Track extend STIDF-class and contain single trips or tracks, objects of class Tracks contain multiple Track objects for a single ID (person, object or tracking device), objects of class TracksCollection contain multiple Tracks objects for different IDs.

Slots of class "Track"

sp: spatial locations of the track points, with length n

time: time stamps of the track points

endTime: end time stamps of the track points

data: data.frame with n rows, containing attributes of the track points

connections: data.frame, with n-1 rows, containing attributes between the track points such as distance and speed

Slots of class "Tracks"

tracks: list with Track objects, of length m

tracksData: data.frame with m rows, containing summary data for each Track object

Slots of class "TracksCollection"

`tracksCollection`: `list` `Tracks` objects, of length p

`tracksCollectionData`: `data.frame` with p rows, containing summary data for each `Tracks` object

Methods

[[`signature(obj = "Track")`: retrieves the attribute element

[[`signature(obj = "Tracks")`: retrieves the attribute element

[[`signature(obj = "TracksCollection")`: retrieves the attribute element

[[<- `signature(obj = "Track")`: sets or replaces the attribute element

[[<- `signature(obj = "Tracks")`: sets or replaces the attribute element

[[<- `signature(obj = "TracksCollection")`: sets or replaces the attribute element

$ `signature(obj = "Track")`: retrieves the attribute element

$ `signature(obj = "Tracks")`: retrieves the attribute element

$ `signature(obj = "TracksCollection")`: retrieves the attribute element

$<- `signature(obj = "Track")`: sets or replaces the attribute element

$<- `signature(obj = "Tracks")`: sets or replaces the attribute element

$<- `signature(obj = "TracksCollection")`: sets or replaces the attribute element

coerce Track,data.framecoerce to `data.frame`

coerce Tracks,data.framecoerce to `data.frame`

coerce TracksCollection,data.framecoerce to `data.frame`

plot `signature(x = "TracksCollection", y = "missing")`: plots sets of sets of tracks

stplot `signature(obj = "TracksCollection")`: plots sets of sets of tracks

Note

`segments` is a `data.frame` form in which track segments instead of track points form a record, with `x0`, `y0`, `x1` and `y1` the start and end coordinates

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

http://www.jstatsoft.org/v51/i07/

Examples

```
library(sp)
library(spacetime)
# t0 = as.POSIXct(as.Date("2013-09-30",tz="CET"))
t0 = as.POSIXct("2013-09-30 02:00:00", tz = "Europe/Berlin")
# person A, track 1:
x = c(7,6,5,5,4,3,3)
y = c(7,7,6,5,5,6,7)
n = length(x)
set.seed(131)
t = t0 + cumsum(runif(n) * 60)
require(rgdal)
crs = CRS("+proj=longlat +datum=WGS84") # longlat
stidf = STIDF(SpatialPoints(cbind(x,y),crs), t, data.frame(co2 = rnorm(n)))
A1 = Track(stidf)
# person A, track 2:
x = c(7,6,6,7,7)
y = c(6,5,4,4,3)
n = length(x)
t = max(t) + cumsum(runif(n) * 60)
stidf = STIDF(SpatialPoints(cbind(x,y),crs), t, data.frame(co2 = rnorm(n)))
A2 = Track(stidf)
# Tracks for person A:
A = Tracks(list(A1=A1,A2=A2))
# person B, track 1:
x = c(2,2,1,1,2,3)
y = c(5,4,3,2,2,3)
n = length(x)
t = max(t) + cumsum(runif(n) * 60)
stidf = STIDF(SpatialPoints(cbind(x,y),crs), t, data.frame(co2 = rnorm(n)))
B1 = Track(stidf)
# person B, track 2:
x = c(3,3,4,3,3,4)
y = c(5,4,3,2,1,1)
n = length(x)
t = max(t) + cumsum(runif(n) * 60)
stidf = STIDF(SpatialPoints(cbind(x,y),crs), t, data.frame(co2 = rnorm(n)))
B2 = Track(stidf)
# Tracks for person A:
B = Tracks(list(B1=B1,B2=B2))
Tr = TracksCollection(list(A=A,B=B))
stplot(Tr, scales = list(draw=TRUE))
stplot(Tr, attr = "direction", arrows=TRUE, lwd = 3, by = "direction")
stplot(Tr, attr = "direction", arrows=TRUE, lwd = 3, by = "IDs")
plot(Tr, col=2, axes=TRUE)
dim(Tr)
dim(Tr[2])
dim(Tr[2][1])
u = stack(Tr) # four IDs
dim(u)
dim(unstack(u, c(1,1,2,2))) # regroups to original
dim(unstack(u, c(1,1,2,3))) # regroups to three IDs
```

```
dim(unstack(u, c(1,2,2,1))) # regroups differently
as(Tr, "data.frame")[1:10,] # tracks separated by NA rows
as(Tr, "segments")[1:10,]   # track segments as records
Tr[["distance"]] = Tr[["distance"]] * 1000
Tr$distance = Tr$distance / 1000
Tr$distance
# work with custum TrackStats function:
MyStats = function(track) {
df = apply(coordinates(track@sp), 2, diff) # requires sp
data.frame(distance = apply(df, 1, function(x) sqrt(sum(x^2))))
}
crs = CRS(as.character(NA))
stidf = STIDF(SpatialPoints(cbind(x,y),crs), t, data.frame(co2 = rnorm(n)))
B2 = Track(stidf) # no longer longlat;
B3 = Track(stidf, fn = MyStats)
all.equal(B3$distance, B2$distance)

# approxTrack:
opar = par()
par(mfrow = c(1, 2))
plot(B2, ylim = c(.5, 6))
plot(B2, pch = 16, add = TRUE)
title("irregular time steps")
i = index(B2)
B3 = approxTrack(B2, seq(min(i), max(i), length.out = 50))
plot(B3, col = 'red', type = 'p', add = TRUE)
B4 = approxTrack(B2, seq(min(i), max(i), length.out = 50), FUN = spline)
plot(B4, col = 'blue', type = 'b', add = TRUE)
# regular time steps:
t = max(t) + (1:n) * 60 # regular
B2 = Track(STIDF(SpatialPoints(cbind(x,y),crs), t, data.frame(co2 = rnorm(n))))
plot(B2, ylim = c(.5, 6))
plot(B2, pch = 16, add = TRUE)
title("constant time steps")
i = index(B2)
B3 = approxTrack(B2)
plot(B3, type = 'p', col = 'red', add = TRUE)
B4 = approxTrack(B2, FUN = spline)
plot(B4, type = 'p', col = 'blue', add = TRUE)

# par(opar) # good to do, but would generate warnings
smth = function(x,y,xout,...) predict(smooth.spline(as.numeric(x), y), as.numeric(xout))
data(storms)
plot(storms, type = 'p')
storms.smooth = approxTracksCollection(storms, FUN = smth, n = 200)
plot(storms.smooth, add = TRUE, col = 'red')
```

Track.idw *Movement smoothing of trajectory pattern*

Description

Movement smoothing of trajectory pattern

Usage

```
Track.idw(X,timestamp,epsilon=epsilon,...)
```

Arguments

X	a list of objects of class "Track"
timestamp	based on secs,mins, ...
epsilon	(optional) movements with length less than epsilon are not considered in the calculation
...	passed to arguments of fucntion idw in spatstat

Details

Performs spatial smoothing to the movements of a list of tracks.

Value

an image of class "im".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

as.Track.arrow, idw

Examples

```
X <- list()
for(i in 1:10){
  m <- matrix(c(0,10,0,10),nrow=2,byrow = TRUE)
  X[[i]] <- rTrack(bbox = m,transform = TRUE)
}
Track.idw(X,timestamp="180 secs")
```

tsqTracks *tsqTracks*

Description

tsqtracks returns a sequance of time based on a list of tracks (or a single object of class "Track"") and an argument timestamp.

Usage

```
tsqTracks(X,timestamp)
```

Arguments

X	either an object of class "Track"" or a list of some objects of class "Track"
timestamp	a timestamp to create the time sequence based on it

Details

This creates a sequence of time based on a track or a list of tracks.

Value

An object of class "POSIXct" or "POSIXt".

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack

Examples

```
library(sp)
library(spacetime)
# t0 = as.POSIXct(as.Date("2013-09-30",tz="CET"))
t0 = as.POSIXct("2013-09-30 02:00:00", tz = "Europe/Berlin")
# person A, track 1:
x = c(7,6,5,5,4,3,3)
y = c(7,7,6,5,5,6,7)
n = length(x)
set.seed(131)
t = t0 + cumsum(runif(n) * 60)
require(rgdal)
crs = CRS("+proj=longlat +datum=WGS84") # longlat
stidf = STIDF(SpatialPoints(cbind(x,y),crs), t, data.frame(co2 = rnorm(n)))
A1 = Track(stidf)
tsqTracks(A1,timestamp = "1 sec")
```

unique.Track *unique.Track*

Description

Removing duplicated points in a track

Usage

```
## S3 method for class 'Track'
unique(x,...)
```

Arguments

x	an object of class "Track"
...	passed to arguments of unique

Details

This function removes duplicated points in an object of class "Track".

Value

An object of class Track with no duplicated point.

Author(s)

Mohammad Mehdi Moradi <moradi@uji.es>

See Also

rTrack, rTracks, rTracksCollection, unique

Examples

```
x <-  rTrack()
unique(x)
```

Index