Package 'anipaths'

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Type Package

Title Animation of Multiple Trajectories with Uncertainty

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Description Animation of observed trajectories using spline-based interpolation (see for example, Buderman, F. E., Hooten, M. B., Ivan, J. S. and Shenk, T. M. (2016), <doi:10.1111/2041-210X.12465> ``A functional model for characterizing long-distance movement behaviour''. Methods Ecol Evol). Intended to be used exploratory data analysis, and perhaps for preparation of presentations.

License GPL-3

RoxygenNote 7.3.2

Depends R (>= 3.5.0)

Imports animation, RColorBrewer, sf, crawl, mgcv, grDevices, ggmap,
dplyr, ellipse, ggplot2, igraph, lubridate, magrittr, mvtnorm,
stringr, tidyr, tidyselect

Suggests knitr, rmarkdown, terra, testthat

VignetteBuilder knitr

LazyData true

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NeedsCompilation no

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Contents

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animate_paths   *animate paths*

Description

Animates telemetry data for the purposed of EDA using smoothing splines to interpolate the observed locations. The animations are particularly useful when examining multiple simultaneous trajectories. The output of the call to animate_paths() should bring up a browser window that shows the animation. Additionally, the images generated in images/ (or else the value set for imgdir) may be used with ffmpeg, latex, or other presentation software that can build animations directly from a sequence of images.

Usage

```
animate_paths(
  paths,
  coord = c("x", "y"),
  Time.name = "time",
  background = NULL,
  bg.axes = TRUE,
  bg.misc = NULL,
  bg.opts = NULL,
  blur.size = 8,
  covariate = NULL,
  covariate.colors = c("black", "white"),
  covariate.legend.loc = "bottomright",
  covariate.thresh = NULL,
  crawl.mu.color = "black",
  crawl.plot.type = "point.tail",
  date.col = "black",
```

```
          delta.t = NULL,
          dev.opts = list(),
          dimmed = NULL,
          ID.name = NULL,
          interpolation_type = "gam",
          interval = 1/12,
          legend.loc = "topright",
          main = NULL,
          max_refit_attempts = 10,
          method = "html",
          n.frames = NULL,
          network = NULL,
          network.colors = NULL,
          network.thresh = 0.5,
          network.times = NULL,
          network.ring.trans = 1,
          network.ring.wt = 3,
          network.segment.trans = 0.5,
          network.segment.wt = 3,
          override = FALSE,
          par.opts = list(),
          paths.proj = "+proj=longlat",
          paths.tranform.crs = "+proj=aea",
          plot.date = TRUE,
          pt.alpha = 0.4,
          pt.cex = 1,
          pt.colors = NULL,
          pt.wd = 1,
          res = 1.5,
          return.paths = FALSE,
          s_args = NULL,
          simulation = FALSE,
          simulation.iter = 12,
          tail.alpha = 0.6,
          tail.colors = "gray87",
          tail.length = 5,
          tail.wd = 1,
          theme_map = NULL,
          times = NULL,
          uncertainty.level = NA,
          uncertainty.type = 1,
          whole.path = FALSE,
          xlim = NULL,
          ylim = NULL,
          verbose = FALSE,
          ...
        )
```

Arguments

paths	Either a `data.frame` with longitudes/eastings, latitudes/northings, IDs, and times (see coord, ID.name, and Time.name), a `SpatialPointsDataFrame` with IDs and times, or a list of data.frames containing the longitudes, latitudes, and times for each individual (with names provided). If all paths are already synchronous, another option for passing the data is to define `paths` as a list of matrices, all with the same number of rows, and to specify the times separately via the next argument. This situation might arise when, for example, locations the user wishes to animated correspond to realizations/sampler from a discrete-time movement model. Covariates may be provided as named columns of the matrices in `paths`.
coord	A character vector of length 2 giving the names of the longitude/easting and latitude/northing columns in the `paths data.frame` (in that order). This is required if `paths` is not a `SpatialPointsDataFrame`.
Time.name	The name of the columns in `paths` gving the observation times. This column must be of class `POSIXt`, or numeric.
background	Three possibilities: (1) A single background image over which animation will be overlayed, or a SpatRaster objects with one layers corresponding to each frame. (2) A list with values `center` (long/lat), `zoom`, and `maptype` (see `ggmap::get_googlemap()`) which will be used to generate a background for the animation based on Google maps tiles. Additional arguments may be added which will be passed to `ggmap::get_googlemap()`. (3) A logical value of `TRUE`, which will cue the function to get the best Google Map tile combination it can come up with. Note: ggmap must be installed for (2) and (3). Note: if you are calling `animate_paths()` several times in a short period of time you may get an error from Google for trying to pull tiles too often (e.g., `Error in download.file(url, destfile = tmp, quiet = !messaging, mode = "wb") : cannot open URL 'http://maps.googleapis...')`. Waiting a minute or so usually solves this.
bg.axes	logical: should animation place axis labels when using a background image (default is `TRUE`). If RGoogleMaps is used to produce background, labels will be "northing" and "easting". Otherwise, the strings given to coord will be used.
bg.misc	Character string which will be executed as R code after generating the background, and before adding trajectories, etc.
bg.opts	Options passed to `plot()` function call that makes background in each frame. For example, this could be used to specify blue ocean and gray land cover if `background` is a MULTIPOLYGON simple features object and `bg.opts = list(bg = "dodgerblue4", col = "gray", border = "gray")`.
blur.size	a integer of the size for blur points; default is 8
covariate	The name of the column in `paths` that identifies the covariate to be mapped to a ring of color around each point.
covariate.colors	
	vector of colors which will be used in their given order to make a color ramp (see `colorRamp()`)
covariate.legend.loc	
	either the location of the covariate legend, or `NA` if no legend is desired

`covariate.thresh`	
	if changed from its default value of `NULL`, the interpolated value of the covariate will be binarized based on this numeric value.
`crawl.mu.color`	color for the main predictions for crawl interpolation; default is black
`crawl.plot.type`	
	a character string of what type of the plot you wish to generate when `interpolation_type = "crawl"`. Default is "point.tail" for points with tails; input "point" for point plot and input "blur" for blur point plot; ; input "blur.point" for blur point with tails.
`date.col`	default is `"black"`
`delta.t`	The gap in time between each frame in the animation. Specify one of `delta.t` or `n.frames`. If both are specified, `delta.t` is used.
`dev.opts`	Options passed to `png()` before creating each frame.
`dimmed`	Numeric vector of individuals to "dim" in the animation. Order corresponds to the order of the ID.name variable, or order of paths list.
`ID.name`	The name of the column in `paths` that identifies each individual. If left as `NULL` (default), a single individual is assumed.
`interpolation_type`	
	a character string of the type of interpolation. Default is "gam" for a generalized addictive model. Use "crawl" to interpolate using `crawl` package. Note: due to the ongoing shift in PROJ4/6 standards, warning about CRS comments may appear.
`interval`	Seconds per frame in animation. Default is 1/12 (or 12 frames per second).
`legend.loc`	passed to first argument of `legend()` function. Default is `"topright"`. `NA` removes legend.
`main`	Title for each frame.
`max_refit_attempts`	
	an integer of number of resampling when the fit for crawl failed to run; default is 10
`method`	either `"html"` (default) or `"mp4"`. The latter requires the user has installed ffmpeg (see `?animation::saveVideo()`).
`n.frames`	The number of frames used to animate the complete time domain of the data.
`network`	Array of dimensions (# individuals, # individuals, `n.frames`) that gives a dyanmic network structure among the individuals.
`network.colors`	A symmetric matrix of dimension `length(paths)` $\times$ `length(paths)` giving the colors associated with each pairwise relationship.
`network.thresh`	Network structure is summarized in the animation in a binary way, regardless of whether or not the `network` is continuously weighted or not. The value of `network.thresh` determines the level below which no connection is shown, and above which an active connection is shown via colored rings and connecting segments.
`network.times`	Numeric vector. If network time grid doesn't match `n.frames`, supply the times at which the network has been evaluated so it can be interpolated using smoothing splines.

network.ring.trans	
	transparency of network segments (default is 1)
network.ring.wt	
	thickness of network rings (default is 3)
network.segment.trans	
	transparency of network segments (default is 0.5)
network.segment.wt	
	thickness of network segments (default is 3)
override	Logical variable toggling where or not to override warnings about how long the animation procedure will take.
par.opts	Options passed to par() before creating each frame.
paths.proj	PROJ.4 string corresponding to the projection of the data. Default is "+proj=longlat".
paths.tranform.crs	
	a PROJ.4 string of coordinate projection transformation based on the animals' location; default is "+proj=aea +lat_1=30 +lat_2=70".
plot.date	Logical variable toggling date text at the time center of the animation.
pt.alpha	alpha value for the points
pt.cex	A numeric value giving the character expansion (size) of the points for each individual. Default is 1.
pt.colors	A vector of colors to be used for each individual in the animation. Default values come from Color Brewer palettes. When a network is provided, this is ignored and individuals are all colored black. If NA, no plot colors are chosen to distinguish individuals. This can be useful when making animations involving a covariate. Consider also setting legend.loc to NA in this case.
pt.wd	size of the points; default is 1
res	Resolution of images in animation. Increase this for higher quality (and larger) images.
return.paths	logical. Default is FALSE, but if TRUE then the interpolated paths are returned and no animation is produced.
s_args	Default is NULL, in which case anipaths attempts to select a reasonable number of knots for the GAM interpolation. Alternatively, the user can provide a list of arguments to mgcv::s() the same length and order as number of unique individuals (i.e., unique(paths[, ID.name])). Each entry in the list should be a named list/vector (e.g., s_args = list(list(k = 10), list(k = 12), ...)).
simulation	logical. Generate simulation predictions to have multiple projects for the animal paths; default is FALSE.
simulation.iter	
	an integer of how many paths the crawl model will generate; default is 5.
tail.alpha	alpha value for the tails
tail.colors	default is "gray87". Can be single color or vector of colors.
tail.length	Length of the tail trailing each individual.
tail.wd	Thickness of tail trailing behind each individual. Default is 1.

theme_map	plot theme for `ggplot`, default is NULL
times	If all paths are already synchronous, another option for passing the data is to define `paths` as a list of matrices, all with the same number of rows, and to specify the times separately via this argument.
uncertainty.level	
	value in (0, 1) corresponding to `level` at which to draw uncertainty ellipses. NA (default) results in no ellipses.
uncertainty.type	
	State what type of uncertainty plot 1 is default for tails more than 1 is amount of predicted trajectories for each unique individual and blurs for blur plot
whole.path	logical. If TRUE (default = FALSE), the complete interpolated trajectories will be plotted in the background of the animation. If `whole.path = TRUE`, consider also setting `tail.length = 0`.
xlim	Boundaries for plotting. If left undefined, the range of the data will be used.
ylim	Boundaries for plotting. If left undefined, the range of the data will be used.
verbose	logical; TRUE prints messages about fitting details
...	other arguments to be passed to `ani.options` to animation options such as the time interval between image frames.

Value

video file, possibly a directory containing the individual images, or interpolated paths.

Examples

```
##
vultures$POSIX <- as.POSIXct(vultures$timestamp, tz = "UTC")
vultures_paths <- vultures[vultures$POSIX > as.POSIXct("2009-03-01", origin = "1970-01-01") &
  vultures$POSIX < as.POSIXct("2009-05-01", origin = "1970-01-01"), ]
animate_paths(
  paths = vultures_paths,
  delta.t = "week",
  coord = c("location.long", "location.lat"),
  Time.name = "POSIX",
  ID.name = "individual.local.identifier"
)
## Not run:
background <- list(
  center = c(-90, 10),
  zoom = 3,
  maptype = "satellite"
)
library(ggmap)
library(RColorBrewer)
COVARIATE <- cos(as.numeric(vultures_paths$timestamp) /
  diff(range(as.numeric(vultures_paths$timestamp))) * 4 * pi)
animate_paths(
  paths = cbind(vultures_paths, COVARIATE),
  delta.t = "week",
```

```
    coord = c("location.long", "location.lat"),
    Time.name = "POSIX", covariate = "COVARIATE",
    covariate.colors = brewer.pal(n = 9, "RdYlGn"),
    ID.name = "individual.local.identifier",
    background = background
)

# animation using crawl interpolation
animate_paths(
    paths = vultures_paths,
    delta.t = "week",
    coord = c("location.long", "location.lat"),
    Time.name = "POSIX",
    ID.name = "individual.local.identifier",
    interpolation_type = "crawl"
)

## End(Not run)

# Run to remove files generated by this function
system("rm -r js; rm -r css; rm -r images; rm index.html")
```

---

blur_point   *blur ellipses function*

Description

blur ellipses function

Usage

```
blur_point(
    x,
    levels = seq(0.001, 1 - 0.1, l = 15),
    alpha_mult,
    col = "black",
    center
)
```

Arguments

x	An object. In the default method the parameter x should be a correlation between -1 and 1 or a square positive definite matrix at least 2x2 in size. It will be treated as the correlation or covariance of a multivariate normal distribution.
levels	contour levels
alpha_mult	multiplier on transparency level
col	default is black
center	two-vector giving center of ellipse

---

check_overwrite   *Check overwrite*

Description

Check overwrite

Usage

```
check_overwrite(method, return.paths, ...)
```

Arguments

method	passed from animate_paths()
return.paths	passed from animate_paths()
...	passed from animate_paths(); used to check for user-specified value for img.name

Value

NULL, unless there is risk of over-writting and the user interrupts animation (FALSE)

---

covariate_interp   *Synchronous interpolation of covariate using either GAM (same as paths) or piece-wise constant if covariate is a factor*

Description

Synchronous interpolation of covariate using either GAM (same as paths) or piece-wise constant if covariate is a factor

Usage

```
covariate_interp(paths, covariate = NULL, Time.name, time.grid, s_args)
```

Arguments

paths	lists of data.frames containing positions, times, and covariate for each individual
covariate	character string giving name of covariate variable in data.frames
Time.name	character string giving name of time variable in data.frames
time.grid	grid of possible times to use for interpolation (individuals will only be interpolated to times within the range of observation times)
s_args	arguments to mgcv::s() for GAM interpolation method

Value

list of interpolated covariate by individual

---

gam_interp   *GAM interpolation using* `mgcv:gam()`.

Description

GAM interpolation using `mgcv:gam()`.

Usage

```
gam_interp(
  formula = NULL,
  y,
  time,
  pred_times,
  se.fit = T,
  s_args = NULL,
  uncertainty.type,
  verbose = F
)
```

Arguments

`formula`	optionally specify formula for `mgcv::gam()` using `y` as response and `time` as predictor.
`y`	observations
`time`	times for observations
`pred_times`	prediction times
`se.fit`	logical default is TRUE; should standard pointwise errors be computed for interpolation
`s_args`	Arguments to `mgcv::s()` can be passed using a named list/vector.
`uncertainty.type`	
	State what type of uncertainty plot 1 is default for tails more than 1 is amount of predicted trajectories for each unique individual and blurs for blur plot
`verbose`	logical; TRUE prints messages about fitting details

Value

interpolated values

---

get_googlemap_min_scale

> *Figure out scale and centering of google map by transforming reported lat long bounding box back to web mercator*

Description

Figure out scale and centering of google map by transforming reported lat long bounding box back to web mercator

Usage

```
get_googlemap_min_scale(map)
```

Arguments

map   ggmap object

Value

scale (factor by which web mercator has been shrunk) and min (leftmost, bottom most coordinate of rectangle)

---

googlemap_proj   *adjust center + scale for google map plotting*

Description

adjust center + scale for google map plotting

Usage

```
googlemap_proj(x, map)
```

Arguments

x   sf object

map   ggmap object

Value

two-column matrix of locations from x projected to match map

---

network_interp | *Synchronous interpolation of network using piece-wise constant interpolation*

Description

Synchronous interpolation of network using piece-wise constant interpolation

Usage

```
network_interp(network = NULL, network.times, time.grid)
```

Arguments

network | array of network observations of dimension (n.indiv, n.indiv, length(network.times))
network.times | vector of times at which network observations are made
time.grid | times at which network will be interpolated

Value

array of dimension n.indiv, n.indiv, length(time.grid))

---

new_alpha | *Get good alpha_mult*

Description

Get good alpha_mult

Usage

```
new_alpha(sd1, sd2)
```

Arguments

sd1 | standard deviation of longitude
sd2 | standard deviation of latitude

Value

scalar value to be used for alpha_mult in blur_point()

---

paths_gam_interp   *Synchronous GAM interpolation of all paths*

Description

Synchronous GAM interpolation of all paths

Usage

```
paths_gam_interp(
  paths,
  coord,
  Time.name,
  time.grid,
  s_args = NULL,
  uncertainty.type,
  verbose = F
)
```

Arguments

paths	lists of data.frames containing positions, times, and covariate for each individual
coord	two-vector of character strings giving names of x and y coordinates in data.frames
Time.name	character string giving name of time variable in data.frames
time.grid	grid of possible times to use for interpolation (individuals will only be interpolated to times within the range of observation times)
s_args	List of arguments to mgcv::s() the same length as number of unique individuals. Each entry in the list should be a named list/vector.
uncertainty.type	
	State what type of uncertainty plot 1 is default for tails more than 1 is amount of predicted trajectories for each unique individual and blurs for blur plot
verbose	logical; TRUE prints messages about fitting details

Value

list of interpolated paths by individual

---

plot.paths_animation   *Plot animation path interpolation*

Description

This is mainly intended as a way to check that the interpolations used in the animation are working as expected.

Usage

```
## S3 method for class 'paths_animation'
plot(x, ..., i = 1, level = 0.05, type = "path", ylim_x = NULL, ylim_y = NULL)
```

Arguments

x	paths_animation object as created through a call to animate_paths().
...	additional arguments passed to plot.
i	index of individual to plot (corresponds to index in unique(paths[, 'ID.name')).
level	confidence level for error bands. NA removes bands.
type	either "path" (default) for two marginal interpolation plots, or "covariate" for a single interpolation plot
ylim_x	y-axis limits for marginal plots (x, easting, etc.)
ylim_y	y-axis limits for marginal plots (y, northing, etc.)

Examples

```
vultures$POSIX <- as.POSIXct(vultures$timestamp, tz = "UTC")
vultures_paths <- vultures[vultures$POSIX > as.POSIXct("2009-03-22", origin = "1970-01-01") &
  vultures$POSIX < as.POSIXct("2009-04-05", origin = "1970-01-01"), ]
interpolated_paths <-
  animate_paths(
    paths = vultures_paths,
    delta.t = 3600 * 6,
    coord = c("location.long", "location.lat"),
    Time.name = "POSIX",
    ID.name = "individual.local.identifier",
    s_args = rep(list(list(k = 10)), 6),
    return.paths = TRUE
  )
plot(interpolated_paths, i = 2)
```

vultures	*GPS locations of turkey vultures.*

Description

A dataset containing a subset of the locations of turkey vultures (2003–2006), with time stamps, from:

Usage

```
vultures
```

Format

A data frame with 215719 rows and 11 variables:

timestamp time of observation

location.long logitude

location.lat latitude

individual.local.identifier identifier for each individual ...

Details

Dodge S, Bohrer G, Bildstein K, Davidson SC, Weinzierl R, Mechard MJ, Barber D, Kays R, Brandes D, Han J (2014) Environmental drivers of variability in the movement ecology of turkey vultures (Cathartes aura) in North and South America. Philosophical Transactions of the Royal Society B 20130195. doi:10.1098/rstb.2013.0195

Bildstein K, Barber D, Bechard MJ (2014) Data from: Environmental drivers of variability in the movement ecology of turkey vultures (Cathartes aura) in North and South America. Movebank Data Repository. doi:10.5441/001/1.46ft1k05

Source

[doi:10.5441/001/1.46ft1k05](doi:10.5441/001/1.46ft1k05) Bildstein K, Barber D, Bechard MJ (2014) Data from: Environmental drivers of variability in the movement ecology of turkey vultures (Cathartes aura) in North and South America. Movebank Data Repository.

whales	*GPS locations of three species of whales.*

Description

A dataset containing locations of whales, with time stamps, from:

Usage

```
whales
```

Format

A data frame with 4303 rows and 4 variables:

timestamp time of observation

location.long logitude

location.lat latitude

individual.local.identifier identifier for each individual ...

Details

Irvine LM, Winsor MH, Follett TM, Mate BR, Palacios DM (2020) An at-sea assessment of Argos location accuracy for three species of large whales, and the effect of deep-diving behavior on location error. Animal Biotelemetry 8:20.

Irvine LM, Follett TM, Winsor MH, Mate BR, Palacios DM (2020) Data from: Study "Blue and fin whales Southern California 2014-2015 - Argos data". Movebank Data Repository. doi:10.5441/001/1.98f5r6d0

Source

doi:10.5441/001/1.98f5r6d0 Irvine LM, Follett TM, Winsor MH, Mate BR, Palacios DM (2020) Data from: Study "Blue and fin whales Southern California 2014-2015 - Argos data". Movebank Data Repository.

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