Package 'moveVis'

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Type Package

Title Movement Data Visualization

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Description Tools to visualize movement data (e.g. from GPS tracking) and temporal changes of environmental data (e.g. from remote sensing) by creating video animations.

License GPL-3

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Imports maptools, ggplot2, grid, rasterVis, raster, sp, geosphere, dismo, utils, grDevices, methods, stats, move, gridExtra, graphics, simecol, plyr, zoo, lubridate, parallel, pbapply, RStoolbox

BugReports http://www.github.com/16eagle/moveVis/issues

SystemRequirements convert from ImageMagick, ffmpeg from FFmpeg

URL http://movevis.org

Suggests testthat

NeedsCompilation no

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R topics documented:

`moveVis-package` *Overview of moveVis tools*

Description

`moveVis` provides tools to visualize movement data of any kind, e. g by creating path animations from GPS point data. The package is under ongoing development, new functionalities are added constantly. The `moveVis` package is closely connected to the `move` package and mainly builds up on `ggplot2`.

Details

At the moment, the package includes the following functions:

`animate_move`, which can create spatial movement data animations as GIF file. Among other funtionalities, the function is able to

- visualize move class point data as (multiple) movement paths,
- display static basemap layers downloaded from Google Maps,
- display static basemap layers provided by the user,
- display dynamic, time-referenced raster data, e. g. to visualize land cover changes etc.,
- compute temporal interpolations from time-referneced raster data,
- create statistic plots, displaying the interaction of the individual movement paths with environmental data. ...

`animate_stats`, which can create animated statistic plots from movement and basemap data as GIF file.

`animate_raster`, which can create animated spatial plots of basemap data as GIF file.

`get_libraries`, a helper function to locate/download/install the extern libraries ImageMagick, FFmpeg and libav and their tools, which are needed for different output file format support.

`get_formats`, a helper function which returns all available output file formats (system-dependent).

Author(s)

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See Also

`animate_move`

animate_move *Animate movement data*

Description

animate_move animates movement data provided as move class objects or a list of them. The function creates an animated GIF or video file and saves it into the output directory. animate_move can be operated in different timing modes (see paths_mode) and with different background layer types (see layer, layer_type and map_type).

Usage

```
animate_move(m, out_dir, conv_dir = "", paths_mode = "true_data",
  paths_na.hold = TRUE, paths_col = "auto", paths_alpha = 1,
  indi_names = NA, layer = "basemap", layer_dt = "basemap",
  layer_int = FALSE, layer_type = "", layer_stretch = "none",
  layer_col = c("sandybrown", "white", "darkgreen"), layer_nacol = "white",
  map_type = "satellite", stats_create = FALSE, static_data = NA,
  static_gg = NA, extent_factor = 1e-04, tail_elements = 10,
  tail_size = 4, img_title = "title", img_sub = "subtitle",
  img_caption = "caption", img_labs = "labs", legend_title = "",
  legend_limits = NA, legend_labels = "auto", map_elements = TRUE,
  time_bar_col = "grey", time_scale = TRUE, time_pos_x = 0.5,
  time_pos_y = 0.05, time_size = 3, scalebar_col = "white",
  scalebar_dist = "auto", north_col = "white", frames_layout = 0,
  frames_nmax = 0, frames_fps = 25, frames_nres = 1, frames_tres = 0,
  frames_width = NA, frames_height = NA, frames_pixres = 80,
  out_name = "moveVis", out_format = "gif", overwrite = FALSE,
  log_level = 1, log_logical = FALSE, ..., conv_cmd = "",
  conv_frames = 100)
```

Arguments

m	list or moveStack class object. Needs to contain one or several move class objects (one for each individual path to be displayed) containing point coordinates, timestamps, projection and individual ID.
out_dir	character. Output directory of the output file.
conv_dir	character. Command of or path to required image/video converter tool. Depends on, what is specified for out_format. If out_format = "gif", animate_move() works with the ImageMagick convert tool. In this case, specify command of or path to the convert tool. You can use get_libraries to find or download/install convert. If out_format is a video format (e.g. "mp4", "mov" ...), animate_move() works with either the FFmpeg ffmepg tool or the libav avconv tool. In this case, specify command of or path to the ffmpeg or avconv tool. See also get_libraries. If not specified, animate_move() trys to find libraries automatically.

paths_mode — character vector. Mode to be used for dealing with time information when displaying multiple individual paths. If set to "true_data", paths are displayed based on true coverage times, showing only time periods that are covered. Time gaps will be skipped. Each frame is linked to a specific true time. If set to "true_time", paths are displayed based on true coverage times. Time gaps will be filled with non-movement frames. This mode is only recommended, if the dataset has no time gaps. Each frame is linked to a specific, true time. If set to "simple", all movement paths are displayed individually with no regard to the true coverage times. Time gaps will be skipped. Each frame displays several times at once, since each individual path has its own time. Default is "true_data".

paths_na.hold — logical. If TRUE, last path location is being hold on frame for NA path locations. If FALSE, path disappears until next path non-NA location. Default is TRUE.

paths_col — character vector. Colours of the individual animation paths. If set to "auto", a predfined colour set will be used. If single colour, all paths will be displayed by the same colour. If more individuals then colours, the colours are repeated.

paths_alpha — numeric. Set transparency of pathes. If set to 0, path is invisible. Default is 1.

indi_names — character. Optional vector of individual names. Length has to be equal to number of individuals in `m`. If NA, individual names are tried to be extracted from `m` using `idData`. Default is NA.

layer — raster, list or character "basemap". Single raster object or list of raster objects to be used as (dynamically changing) basemap layer. Default is `"basemap"` to download a static basemap layer. Use a rasterBrick class object and set layer_type to "RGB" to compute a RGB basemap.

layer_dt — POSIXct vector or list. Single POSIXct date/time stamp or list of POSIXct date/time stamps representing the acquisition dates of the `layer` raster objects.

layer_int — logical. Whether to interpolate the basemap layer objects over time, if several are provided (`TRUE`), or to display them one after another depending on the animation time frame that is displayed (`FALSE`). Default is `FALSE`.

layer_type — charachter. Layer type. Either "RGB" (if layer is a rasterBrick class onejct), "gradient" or "discrete". Default is "RGB". Ignored, if `layer = "basemap"`.

layer_stretch — character. Ignored, if `layer_type` is not "RGB". Either "none", "lin", "hist", "sqrt" or "log" for no stretch, linear, histogram, square-root or logarithmic stretch. Default is "none".

layer_col — character vector. Two or more colours to be used for displaying the background layer. If `layer_type = "gradient"`, a colour ramp between the colous is calcualted. If `layer_type = "discrete"`, the colours will be used per value range. Ignored, if `layer_type = "RGB"`.

layer_nacol — character. Colour to be displayed for NA values. Default is "white".

map_type — character. Static basemap type. Chosse from "roadmap", "satellite", "hybrid", "terrain".

stats_create — logical. `TRUE` to create statistic plots side by side with the spatial plot. Use the arguments explained for `animate_stats` to adjust the plotting behaviour. Default is `FALSE`.

`static_data` data.frame. Data (e.g. static points) to be displayed within the spatial plot of the output animation. At least, "x", "y" columns for the coordinates and "names" for the naming of the point have to be included. If "static_gg" remains unspecified, "static_data" is plottet as points to the output map, annotated with their namings. Points outside the frame extent are not displayed. See "static_gg" for further options.

`static_gg` character. One or several `ggplot2` functions, concatenated by "+" specifying how "static_data" should be displayed, e.g. using `geom_point` and `geom_text` for displaying points annotated with text. `ggplot2 data` and `aes, aes_` arguments etc. need to referr to the columns specified in "static_data". As default, "static_data" is plotted as `geom_point` and `geom_label`.

`extent_factor` numeric. Defines the distance between the spatial extents of the movement data set and the basemap as proportion of the axis distance. Default is 0.0001. The higher the value, the larger the basemap extent. Ignored, if `layer` = "basemap".

`tail_elements` numeric. Number of points to be displayed as path tail of the animation paths. Default is 10.

`tail_size` numeric. Size of the first tail element. Default is 4.

`img_title` character. Titel to be displayed above the animated plot. If not specified, no title will be displayed.

`img_sub` character. Subtitel to be displayed underneath the title. If not specified, no subtitle will be displayed.

`img_caption` character. Caption to be displayed underneath the plot. If not specified, no caption will be displayed.

`img_labs` character. Axis titles to be displayed at the x and y axis of the plot. If not specified, labs will be computed depending on the projection or will be "x" and "y".

`legend_title` character. Title to be displayed above the basemap layer legend (if layer_type is not `"RGB"`). Ignored, if `layer = "basemap"`.

`legend_limits` numeric vector. Fixed minimum and maximum limit values of the legend (gradient layer type). Default is NA for data-depending minimum and maximum values. Ignored, if `layer_type` is "discrete" or "RGB".

`legend_labels` character vectors. Label for each legend break class. If set to "auto", values are displayed. Default is "auto".

`map_elements` logical. If `FALSE`, map elements (north arrow and scale bar) are hidden. Default is `TRUE`.

`time_bar_col` character. Colour of the time progress bar on the top edge of the map. Default is "grey".

`time_scale` logical. If `FALSE`, time scale is hidden. Default is `TRUE`.

`time_pos_x` numeric between 0 and 1, defines the relative position of the time scale display in the x direction. Default is 0.5 (centered).

`time_pos_y` numeric between 0 and 1, defines the relative position of the time scale display in the y direction. Default is 0.06 (top).

`time_size` numeric. Defines the font size of the time scale display. Default is 3.

scalebar_col	character. Colour of the scalebar text. Default is "white".
scalebar_dist	numeric. Distance represented by the scalebar in kilometers.
north_col	character. Colour of the north arrow. Default is "white".
frames_layout	matrix. Optional layout. Define, which plots should be placed where using a matrix representing the GIF/video frame. Matrix elements can be the following plot identifiers: "map" for the spatial plot, "st_all", "st_per" for the overall and periodic stats plot or "st_allR", "st_perR", "st_allG", "st_perG", "st_allB", "st_perB" for the overall and periodic stats plots per band, when using `layer_type = "RGB"`, and 'st_leg' for a stats legend. Alternatively, integers from 1 to 8 corresponding to the described order can be used. Plots not mentioned using `frames_layout` identifiers are not displayed. If set to 0, layout is generated automatically. Default is 0.
frames_nmax	numeric. Number of maximum frames. If set, the animation will be stopped, after the specified number of frames is reached. Default is 0 (displaying all frames).
frames_fps	numeric. Frames to display per second (FPS). Note that the `gif` format only can handle FPS out of 100, e.g. 25. In that case, `frames_fps` input is rounded. Default is 25.
frames_nres	numeric. Interval of which frames of all frames should be used (nth elements). Default is 1 (every frame is used). If set to 2, only every second frame is used.
frames_tres	numeric. Defines temporal output resolution in seconds, 'm' should be interpolated to (linear interpolation). If 0, temporal resolution is detected automatically. Default is 0.
frames_width	numeric. Number of pixels of frame width. Default is 600 (with stats plots 1000).
frames_height	numeric. Number of pixels of frame height. Defualt is 600.
frames_pixres	numeric. Resolution of output file in pixel in ppi. The higher the ppi, the higher frames_height and frames_width should be to avoid large fonts and overlaps. Default is 80.
out_name	character. Name of the output file. Default is "moveVis".
out_format	character. Output format, e.g. "gif", "avi", "3gp", "mov", "mpeg", "mp4". Use `get_formats` to get all supported file formats on your system. "gif" is recommended for short animations only (recommended max. frame number around 200 frames; GIF frames are unlimited, but compution time will be very long). Use a video format for long animations. Format "gif" requires ImageMagick, all other video formats require FFmpeg ('ffmpeg') or libav ('avconv') to be installed. For that, also see `get_libraries`.
overwrite	logical. If TRUE, files with equal file names to `out_name` will be overwritten. Default is FALSE.
log_level	numeric. Level of console output given by the function. There are three log levels. If set to 3, no messages will be displayed except erros that caused an abortion of the process. If set to 2, warnings and errors will be displayed. If set to 1, a log showing the process activity, wanrnings ans errors will be displayed.
log_logical	logical. For large processing schemes. If `TRUE`, the function returns `TRUE` when finished processing succesfully.

...	optional arguments. All arguments taken by animate_stats can be handed over to animate_move as well to create sidy-by-side spatial and statistic plot animations (see animate_stats).
conv_cmd	character. Recommended for expert use only. Passes additional command line options to the conversion command, e.g. with a convert call adding '-limit' for memory ressource handling. For details, see check the documentations of ImageMagick convert, FFmpeg ffmpeg and libav avconv.
conv_frames	numeric. Recommended for expert use only. Only used, if out_format = "gif". Number of frames to be used for creating GIF segments that will be assembled to a final GIF file. Correct number depends on system performance and total frames number. Default is 100. Ignored, if out_format is not "gif".

Details

Make sure you have run get_libraries before you use moveVis for the first time: Depending on the selected output format (out_format, animate_move either needs the convert tool of the ImageMagick software package (.gif format) or either ffmpeg from FFmpeg or avconv from libav (video formats). The command or directory to the convert tool needs to be provided with conv_dir. Please use get_libraries to search for the needed libraries and command/tool directories on your system or to automatically download and install the required software. See get_libraries and out_format and conv_dir for details.

animate_move preprocesses your move data depending on the state of the data (see paths_mode and frames_tres). animate_move is based on ggplot2.

Value

None or logical (see log_logical). The output file is written to the ouput directory.

Author(s)

Jakob Schwalb-Willmann

See Also

get_libraries, animate_stats, animate_raster

Examples

```
## Not run:
#Load move and moveVis packages
library(move)
library(moveVis)

#Get the sample data from the moveVis package (a data.frame)
data("move_data")
move_data$dt <- as.POSIXct(strptime(move_data$dt, "%Y-%m-%d %H:%M:%S", tz = "UTC"))

#Create moveStack object including multiple individuals from the data.frame
#alternatively, use the move package to download data directly from movebank.org
```

```
m <- move(move_data$lon, move_data$lat, proj=CRS("+proj=longlat +ellps=WGS84"),
                 time = move_data$dt, animal=move_data$individual, data=move_data)

#Find the command or directory to convert tool of ImageMagick
conv_dir <- get_libraries()

#Specify the output directory, e.g.
out_dir <- paste0(getwd(),"/test")

#Specify some optional appearance variables
img_title <- "Movement of the white stork population at Lake Constance, Germany"
img_sub <- paste0("including individuals ",paste(rownames(idData(m)), collapse=', '))
img_caption <- "Projection: Geographical, WGS84; Sources: Movebank 2013; Google Maps"

#Call animate_move() with an automatic basemap from Google, maximum frames at 50
#output format "gif"
animate_move(m, out_dir, conv_dir, tail_elements = 10,
             paths_mode = "true_data", frames_nmax = 50,
             img_caption = img_caption, img_title = img_title,
             img_sub = img_sub, log_level = 1, extent_factor = 0.0002,
             out_format = "gif")

#Improve your animation by adding a static points layer
static_data <- data.frame(x = c(8.94,8.943), y = c(47.75,47.753), names = c("Site 1","Site 2"))

#Call animate_move() with "static_data" added
#use another output format, e.g. "mov"
animate_move(m, out_dir, conv_dir, tail_elements = 10,
             paths_mode = "true_data", frames_nmax = 50,
             img_caption = img_caption, img_title = img_title,
             img_sub = img_sub, log_level = 1, extent_factor = 0.0002,
             static_data=static_data, out_format = "mov")

#Try a different paths_mode: Instead of "true_data" use "simple"
#output format "mp4". Longer videos then 100-200 frames should not be GIFs
animate_move(m, out_dir, conv_dir, tail_elements = 10,
             paths_mode = "simple", frames_nmax = 50,
             img_caption = img_caption, img_title = img_title,
             img_sub = img_sub, log_level = 1, extent_factor = 0.0002,
             static_data=static_data, out_format = "mp4")

#Use your own basemap by adding lists of rasters and of timestamps
data("basemap_data")
layer = basemap_data[[1]] #this is a example MODIS NDVI dataset
layer_dt = basemap_data[[2]] #this is a corresponding date/time list

#Call animate_move with NDVI data as basemap
#layer_type is "gradient", since NDVI values are continuous
animate_move(m, out_dir, conv_dir, tail_elements = 10, layer_type = "gradient",
           paths_mode = "true_data", frames_nmax = 50, layer =layer, layer_dt = layer_dt,
             img_caption = img_caption, img_title = img_title,
             img_sub = img_sub, log_level = 1, extent_factor = 0.0002)
```

```
#How do your moving individuals interact with their environments?
#Use "stats_create" to create statistics plots
animate_move(m, out_dir, conv_dir, tail_elements = 10, layer_type = "gradient",
            paths_mode = "true_data", frames_nmax = 50, layer =layer, layer_dt = layer_dt,
              img_caption = img_caption, img_title = img_title,
              img_sub = img_sub, log_level = 1, extent_factor = 0.0002,
              stats_create = TRUE)

#If you just want those stats plots, use animate_stats()

#Use "frames_layout" to change the layout of your animation
#e.g. change the position of st_all and st_per
frames_layout <-  rbind(c("map","map","map","st_all","st_leg"),
                        c("map","map","map","st_per","st_leg"))

#or equalize the sizes of spatial map and stats plots
frames_layout <-  rbind(c("map","st_all","st_per","st_leg"))

animate_move(m, out_dir, conv_dir, tail_elements = 10, layer_type = "gradient",
            paths_mode = "true_data", frames_nmax = 50, layer =layer, layer_dt = layer_dt,
              img_caption = img_caption, img_title = img_title,
              img_sub = img_sub, log_level = 1, extent_factor = 0.0002,
              stats_create = TRUE, frames_layout=frames_layout)

## End(Not run)
```

`animate_raster` *Animate raster data*

Description

`animate_raster` animates raster data provided as list of `raster` class objects. The function creates an animated GIF or video file and saves it into the output directory.

Usage

```
animate_raster(layer, out_dir, conv_dir = "convert", layer_dt = NULL,
  layer_type = "gradient", layer_stretch = "none",
  layer_col = c("sandybrown", "white", "darkgreen"), layer_nacol = "white",
  ...)
```

Arguments

`layer`	list. List of raster objects.
`out_dir`	character. Output directory of the output file.
`conv_dir`	character. Command of or path to required image/video converter tool. Depends on, what is specified for `out_format`. If `out_format = "gif"`, animate_move() works with the ImageMagick `convert` tool. In this case, specify command of

	or path to the convert tool. You can use get_libraries to find or download/install convert. If out_format is a video format (e.g. "mp4", "mov" ...), animate_move() works with either the FFmpeg ffmepg tool or the libav avconv tool. In this case, specify command of or path to the ffmpeg or avconv tool. See also get_libraries. If not specified, animate_move() trys to find libraries automatically.
layer_dt	POSIXct or vector. Optional vector of POSIXct date/time stamps corresponding to the acquisition dates of the layer raster objects to display a time scale.
layer_type	charachter. Layer type. Either "RGB" (if layer is a rasterBrick class onejct), "gradient" or "discrete". Default is "RGB". Ignored, if layer = "basemap".
layer_stretch	character. Ignored, if layer_type is not "RGB". Either "none", "lin", "hist", "sqrt" or "log" for no stretch, linear, histogram, square-root or logarithmic stretch. Default is "none".
layer_col	character vector. Two or more colours to be used for displaying the background layer. If layer_type = "gradient", a colour ramp between the colous is calcualted. If layer_type = "discrete", the colours will be used per value range. Ignored, if layer_type = "RGB".
layer_nacol	character. Colour to be displayed for NA values. Default is "white".
...	additional arguments, see animate_move.

Details

animate_raster is based on ggplot2. Depending on the selected output format (out_format, it either needs the convert tool of the ImageMagick software package (.gif format) or either ffmpeg from FFmpeg or avconv from libav (video formats). The command or directory to the convert tool needs to be provided with conv_dir. Please use get_libraries to search for the needed libraries and command/tool directories on your system or to automatically download and install the required software. See get_libraries and out_format and conv_dir for details.

Value

None or logical (see log_logical). The output GIF or video file is written to the ouput directory.

Author(s)

Jakob Schwalb-Willmann

See Also

get_libraries, animate_move,

Examples

```
## Not run:
#Create a list of several raster objects to be displayed one after another
#If layer_type = RGB, use a brick class obejct with RGB bands!
data("basemap_data") #example MODIS dataset
layer <- basemap_data[[1]] #list of rasters
```

```
#Get your convert directory/command
conv_dir <- get_libraries()

#Specify the output directory, e.g.
out_dir <- "/out/test"

#Call animate_raster
animate_raster(layer,out_dir = out_dir, conv_dir = conv_dir, layer_type = "gradient",
               out_format = "gif")

#use another file format for longer videos
animate_raster(layer,out_dir = out_dir, conv_dir = conv_dir, layer_type = "gradient",
               out_format = "mov")

## End(Not run)
```

`animate_stats` *Animate movement data statistics*

Description

`animate_stats` animates statistic plot from movement data provided as `move` class objects or a list of them and basemap data provided as `raster`. It extracts basemap values of pixels that are part of the movement paths and visualizes frequencies per value. The function creates an animated GIF or video file and saves it into the output directory. See also `animate_move`.

Usage

```
animate_stats(m, out_dir, conv_dir = "convert", layer = "basemap",
  layer_dt = "basemap", layer_int = FALSE, layer_type = "",
  val_limits = NA, paths_col = "auto", paths_mode = "true_data",
  stats_type = "", stats_gg = "", stats_digits = 1, stats_tframe = 5,
  stats_title = "", frames_layout = 0, frames_nmax = 0, frames_fps = 25,
  frames_nres = 1, frames_tres = 0, frames_width = 800,
  frames_height = 300, frames_pixres = 80, out_name = "moveVis_ani",
  out_format = "gif", overwrite = FALSE, log_level = 1,
  log_logical = FALSE)
```

Arguments

`m`	list or `moveStack` class object. Needs to contain one or several `move` class objects (one for each individual path to be displayed) containing point coordinates, timestamps, projection and individual ID.
`out_dir`	character. Output directory of the output file.

conv_dir — character. Command of or path to required image/video converter tool. Depends on, what is specified for out_format. If out_format = "gif", animate_move() works with the ImageMagick convert tool. In this case, specify command of or path to the convert tool. You can use get_libraries to find or download/install convert. If out_format is a video format (e.g. "mp4", "mov" ...), animate_move() works with either the FFmpeg ffmepg tool or the libav avconv tool. In this case, specify command of or path to the ffmpeg or avconv tool. See also get_libraries. If not specified, animate_move() trys to find libraries automatically.

layer — raster, list or character "basemap". Single raster object or list of raster objects to be used as (dynamically changing) basemap layer. Default is "basemap" to download a static basemap layer. Use a rasterBrick class object and set layer_type to "RGB" to compute a RGB basemap.

layer_dt — POSIXct vector or list. Single POSIXct date/time stamp or list of POSIXct date/time stamps representing the acquisition dates of the layer raster objects.

layer_int — logical. Whether to interpolate the basemap layer objects over time, if several are provided (TRUE), or to display them one after another depending on the animation time frame that is displayed (FALSE). Default is FALSE.

layer_type — charachter. Layer type. Either "RGB" (if layer is a rasterBrick class onejct), "gradient" or "discrete". Default is "RGB". Ignored, if layer = "basemap".

val_limits — numeric vector. Fixed minimum and maximum limit values of the legend (gradient layer type). Default is NA for data-depending minimum and maximum values. Ignored, if layer_type is "discrete" or "RGB".

paths_col — character vector. Colours of the individual animation paths. If set to "auto", a predfined colour set will be used. If single colour, all paths will be displayed by the same colour. If more individuals then colours, the colours are repeated.

paths_mode — character vector. Mode to be used for dealing with time information when displaying multiple individual paths. If set to "true_data", paths are displayed based on true coverage times, showing only time periods that are covered. Time gaps will be skipped. Each frame is linked to a specific true time. If set to "true_time", paths are displayed based on true coverage times. Time gaps will be filled with non-movement frames. This mode is only recommended, if the dataset has no time gaps. Each frame is linked to a specific, true time. If set to "simple", all movement paths are displayed individually with no regard to the true coverage times. Time gaps will be skipped. Each frame displays several times at once, since each individual path has its own time. Default is "true_data".

stats_type — character. Defines which standard plot design should be used. Select either "line" or "bar". Ignored, if stats_gg is used.

stats_gg — character. Enables usage of ggplot2 syntax for plot design. If set, stats_type is ignored. See details for information on the statistic data structure to be used by the user defined plot function.

stats_digits — numeric. Defines how detailed the statistic plot should be as number of decimals. Values with more decimals are rounded. Default is 1 for one decimal.

stats_tframe — numeric. Defines the temporal range of the periodic stats plot. Default is 5 meaning that five time frames back from the displayed frame are evaluated.

`stats_title` character vector. Optional plot titles. Two character strings within a vector.

`frames_layout` matrix. Optional layout. Define, which plots should be placed where using a matrix representing the GIF/video frame. Matrix elements can be the following plot identifiers: "map" for the spatial plot, "st_all", "st_per" for the overall and periodic stats plot or "st_allR", "st_perR", "st_allG", "st_perG", "st_allB", "st_perB" for the overall and periodic stats plots per band, when using `layer_type = "RGB"`, and 'st_leg' for a stats legend. Alternatively, integers from 1 to 8 corresponding to the described order can be used. Plots not mentioned using `frames_layout` identifiers are not displayed. If set to 0, layout is generated automatically. Default is 0.

`frames_nmax` numeric. Number of maximum frames. If set, the animation will be stopped, after the specified number of frames is reached. Default is 0 (displaying all frames).

`frames_fps` numeric. Frames to display per second (FPS). Note that the `gif` format only can handle FPS out of 100, e.g. 25. In that case, `frames_fps` input is rounded. Default is 25.

`frames_nres` numeric. Interval of which frames of all frames should be used (nth elements). Default is 1 (every frame is used). If set to 2, only every second frame is used.

`frames_tres` numeric. Defines temporal output resolution in seconds, 'm' should be interpolated to (linear interpolation). If 0, temporal resolution is detected automatically. Default is 0.

`frames_width` numeric. Number of pixels of frame width. Default is 600 (with stats plots 1000).

`frames_height` numeric. Number of pixels of frame height. Defualt is 600.

`frames_pixres` numeric. Resolution of output file in pixel in ppi. The higher the ppi, the higher frames_height and frames_width should be to avoid large fonts and overlaps. Default is 80.

`out_name` character. Name of the output file. Default is "moveVis".

`out_format` character. Output format, e.g. "gif", "avi", "3gp", "mov", "mpeg", "mp4". Use `get_formats` to get all supported file formats on your system. "gif" is recommended for short animations only (recommended max. frame number around 200 frames; GIF frames are unlimited, but compution time will be very long). Use a video format for long animations. Format "gif" requires ImageMagick, all other video formats require FFmpeg ('ffmpeg') or libav ('avconv') to be installed. For that, also see `get_libraries`.

`overwrite` logical. If TRUE, files with equal file names to `out_name` will be overwritten. Default is FALSE.

`log_level` numeric. Level of console output given by the function. There are three log levels. If set to 3, no messages will be displayed except erros that caused an abortion of the process. If set to 2, warnings and errors will be displayed. If set to 1, a log showing the process activity, wanrnings ans errors will be displayed.

`log_logical` logical. For large processing schemes. If `TRUE`, the function returns `TRUE` when finished processing succesfully.

Details

animate_stats is a wrapper function of animate_move to create single statistic plots without spatial plotting. For statistic plot animations sidy-by-side with spatial plot animations, use animate_move (see stats_create argument). The function can handle all arguments taken by animate_stats as well.

Use stats_gg to provide an own ggplot2 plot design as shown in the examples. The statistics are stored for both plots (periodic and accumulated) withn the variable stats_obj[[k]][[b]][[x]] (list of two, indexed by k ranging from 1 to 2 for each plot). Both stats_obj first-level lists contain one list per band (one list or three lists, if 'RGB', indexed by b). These second-level lists contain the stats elements framewise for each time step. For this, see the stats_gg example. The variable cols (list of two, one per plot) contains the defined colour values and namings.

Value

None or logical (see log_logical). The output GIF or video file is written to the ouput directory.

Author(s)

Jakob Schwalb-Willmann

See Also

get_libraries

Examples

```
## Not run:
#Load move and moveVis packages
library(move)
library(moveVis)

#Get the sample data from the moveVis package
data("move_data")
move_data$dt <- as.POSIXct(strptime(move_data$dt, "%Y-%m-%d %H:%M:%S", tz = "UTC"))

#Create moveStack object including multiple individuals
data_ani <- move(move_data$lon, move_data$lat, proj=CRS("+proj=longlat +ellps=WGS84"),
                 time = move_data$dt, animal=move_data$individual, data=move_data)

#Load basemap MODIS NDVI data
data("basemap_data")
layer = basemap_data[[1]]
layer_dt = basemap_data[[2]]

#Find command or directory to convert tool of ImageMagick
conv_dir <- get_libraries()

#Specify the output directory, e.g.
out_dir <- "/out/test"
#or to a temporary directory:
out_dir <- paste0(tempdir(),"/test")
```

```
dir.create(out_dir)


#Call animate_stats()
animate_stats(data_ani, out_dir, conv_dir = conv_dir,
              layer=layer, layer_dt = layer_dt, layer_type = "gradient",
              stats_digits = 1, stats_type = "bar", out_name = "moveVis_ani",
              log_level = 1,frames_nmax = 60)

stats_gg <- 'ggplot(data = stats_obj[[k]][[b]][[x]],
             aes_(x = ~val, y = ~value, colour = ~variable)) +
             geom_line() + geom_point() + theme_bw() + theme(aspect.ratio=1) +
             scale_y_continuous(expand = c(0,0),limits = c(0,stats_max[k])) +
             scale_x_continuous(expand = c(0,0)) +
             scale_color_manual(name= "",values = cols) +
             labs(x = "Basemap Value", y="Frequency",
                  title=stats_title[[b]][[k]], label=c("123","456"))+
             theme(plot.title = element_text(hjust = 0.5),
                  plot.subtitle = element_text(hjust = 0.5))'

#Call animate_stats() with stats_gg
animate_stats(data_ani, out_dir, conv_dir = conv_dir,
              layer=layer, layer_dt = layer_dt, layer_type = "gradient",
              stats_digits = 1, stats_gg = stats_gg, out_name = "moveVis_ani",
              log_level = 1,frames_nmax = 60)

## End(Not run)
```

---

basemap_data *MODIS NDVI 2013 example data of Lake Constance area, Germany*

Description

Dataset containing ten MODIS NDVI scenes of 2013 covering the Lake Constance area.

Usage

```
basemap_data
```

Format

List containing two lists of equal lengths: a list of rasters containing 10 MODIS NDVI raster class objects and a list of corresponding POSIXct class timestamp objects.

Details

The example data have been pre-processed and have euqal extents and projections.

Source

MODIS 2013 freely available data, acsessed using MODIS R package

---

get_formats *Get all available output file formats*

Description

get_formats returns all available file formats that can be used with animate_move (out_format). The available output formats depend on the additional libraries that are installed on your system (see get_libraries).

Usage

```
get_formats(tool = "auto")
```

Arguments

tool	character. Default is "auto" to return all available formats. If set to either 'convert', 'ffmpeg' or 'avconv', the output formats made available by one of these specific library tools are returned.

Value

A character vector containing available output formats. Each vector element can serve as input to the out_format argument of animate_move.

Author(s)

Jakob Schwalb-Willmann

See Also

get_libraries

Examples

```
## Not run:
#Get all formats available from the currently installed libraries
formats <- get_formats()
print(formats)

#For example, use the output as input to animate_move() out_format argument
out_format <- formats[1]

## End(Not run)

#Get formats provided by specifc tool
formats <- get_formats(tool = "convert")
```

`get_libraries` *Detect extern system libraries needed by moveVis*

Description

`get_libraries` trys to detect the libraries on your system that are needed by moveVis to be able to deal with different output file formats. get_libraries() searches for'convert' form the ImageMagick library (needed for .gif support), 'ffmpeg' from the FFmpeg library or 'avconv' from the 'libav-tools' library (both needed for video support). You can execute get_libraries() to make sure, these libraries are correctly installed on your system. It is recommended to have ImageMagick including 'convert' and FFmpeg including 'ffmpeg' installed to gain support of all available output file formats. The function's return can serve as `conv_dir` input to the animate_move() function.

`get_imconvert` is an deprecated alias function of `get_libraries` inlcuded for compatibility reasons that does the same as `get_libraries`, but is only checking for the `convert` tool of ImageMagick. It is recommended to use `get_libraries` instead.

Usage

```
get_libraries(lib.tool = "all", ...)

get_imconvert()
```

Arguments

`lib.tool`	character. Vector of libraries to look for. This can be either 'convert', 'ffmpeg', 'avconv' or a combination. Default is "all" to check for all possible libraries.
`...`	additional arguments. Currently not used.

Details

The following tools and libraries are needed by moveVis:

- the `convert` tool of ImageMagick to support the GIF format
- the `ffmpeg` tool of FFmpeg to support video formats
- alternatively to ffmpeg, the `avconv` tool of libav-tools to support video formats.

It is recommmended to have both ImageMagick and one of the mentioned video libraries installed to be able to create all output formats with the animate_move() function (see argument `out_format` of animate_move)

If you are running Windows or macOS, use the download links below to install the required software:

- ImageMagick: https://www.imagemagick.org/script/download.php)
- FFmpeg from https://www.ffmpeg.org/download.html
- libav from https://libav.org/download/

If you are running macOS, an installation via a package manager such as 'brew' is recommended.

If you are running Linux, execute the commands below to install the required software:

- ImageMagick: `sudo apt-get install imagemagick`
- ffmpeg: `sudo apt-get install ffmpeg`
- libav: `sudo apt-get install libav-tools`

Value

A character vector including all found commands or directories to the needed tools of the requested libraries. The return can serve as `conv_dir` input to the `animate_move` function.

Author(s)

Jakob Schwalb-Willmann

See Also

`animate_move`

Examples

```
#conv_dir of the animate_move() function
conv_dir <- get_libraries()
```

---

move_data *Movement data of a White Stork population located nearby Lake Constance, Germany*

Description

Dataset containing longitude/latitude point cooridnates and acquisition times of several white stork individuals of a population located nearby Lake Constance.

Usage

```
move_data
```

Format

Data frame containing 2408 rows and 5 variables

Details

- lon. Longitude
- lat. Latitude
- individual. Name of the individual
- population. Name of the popualtion
- dt. Date and timestamps (to be used e. g. as POSIXct) ...

The example data have been pre-processed as explained in the examples. Please note that a very basic moving-/non-moving segmentation algorithm has been used in order to keep the code simple. The provided code and data cannot be applied for actual data analysis, only adequate for movement data visualization!

Source

Movebank (2013): URL http://www.movebank.org/

Examples

```
#DISCLAIMER: The provided code and data cannot be applied for actual data analysis
#and should only show the derivation of the example data provided with moveVis.
#This code is only adequate for movement data visualization.

## Not run:
#Calculate start/stop times, FUNCTION
st_times <- function(data){
  for(i in 1:length(data)){
    if(i == 1){
      start_dt <- data[[i]]$dt[1]
      stop_dt <- data[[i]]$dt[length(data[[i]]$dt)]
    }else{
      start_dt <- c(start_dt, data[[i]]$dt[1])
      stop_dt <- c(stop_dt, data[[i]]$dt[length(data[[i]]$dt)])
    }
  }
  return(list(start_dt,stop_dt))
}
#Distance recalculation, FUNCTION
calc_dist <- function(data){
  p1 <- data[1:(length(data$lon)-1),1:2]
  p2 <- data[2:length(data$lon),1:2]
  data$dist_m <- NA
  data$dist_m[2:length(data$dist_m)] <- distGeo(p1,p2)
  return(data)
}

#Moving/non-moving segmentator, FUNCTION
class_moving <- function(data,resting_rad){
  data$moving <- 0
  data$moving[which(data$dist_m >= resting_rad)] <- 1
  return(data)
}
```

```
#Read data
data_dir <- "/path/to/movedata.txt" #In this case, an ASCII file with multiple populations
dr <- read.table(data_dir,header=TRUE,sep=";")
pop_levels <- levels(dr$population)
pop_levels_n <- length(pop_levels)

#Differentiate data per population
for(i in 1:pop_levels_n){
  if(i == 1){
    pop_subset <- list(subset(dr, population == pop_levels[i]))
  }else{
    pop_subset <- c(pop_subset,list(subset(dr, population == pop_levels[i])))
  }
}

#Differentiate data per individual
indi_levels <- levels(dr$individual)
indi_levels_n <- length(indi_levels)
for(i in 1:indi_levels_n){
  if(i == 1){
    indi_subset <- list(subset(dr, individual == indi_levels[i]))
  }else{
    indi_subset <- c(indi_subset,list(subset(dr, individual == indi_levels[i])))
  }
}

#Compute animation input list with all individuals per population
pop_select <- 2 #Selectin a population within the data
match_indi_subs <- as.integer(na.omit(match(indi_levels,pop_subset[[pop_select]]$individual)))
for(i in 1:length(match_indi_subs)){
  if(i == 1){
    indi_subset_pop <- list(pop_subset[[pop_select]][match_indi_subs[i]:
    (match_indi_subs[i+1]-1),])
  }else{
    if(i != length(match_indi_subs)){
      indi_subset_pop[i] <- list(pop_subset[[pop_select]][match_indi_subs[i]:
         (match_indi_subs[i+1]-1),])
    }else{
      indi_subset_pop[i] <- list(pop_subset[[pop_select]][match_indi_subs[i]:
         length(pop_subset[[pop_select]][,1]),])
    }
  }
}

#Calculate dt stamps, extract start_dt and stop_dt for all arrays
for(i in 1:length(indi_subset_pop)){
  dt <- c(paste0(indi_subset_pop[[i]]$date, " ",indi_subset_pop[[i]]$time))
  dt_stamps <- as.POSIXct(strptime(dt, "%Y-%m-%d %H:%M:%S", tz = "UTC"))
  indi_subset_pop[[i]]$dt <- align.time(dt_stamps, n=60)
}
start_dt <- st_times(indi_subset_pop)[[1]]
stop_dt <- st_times(indi_subset_pop)[[2]]
```

```
#Animal specifications, here for the White Stork
max_speed <- 45
max_speed_min <- max_speed/60 #km/min
tolerance_m_min <- 50 #meter
temp_res <- 5 #for simplicity, we do not detect the temp. resolution automatically here

max_speed_spec <- max_speed_min*temp_res #km/temp_res
max_dist_m <- (max_speed_spec*1000)+tolerance_m_min #m/temp_res + tolerance range in m/temp_res

#Clean up individual data by defined props (eliminating peaks etc.), store them per individual
for(i in 1:length(indi_subset_pop)){
  data_clean <- indi_subset_pop[[i]]
  no_peaks <- FALSE
  while(no_peaks == FALSE){
    data_clean <- calc_dist(data_clean)
   dist_peaks <- which(is.na(data_clean$dist_m) == FALSE & data_clean$dist_m >= max_dist_m)
    if(length(dist_peaks) <= 1){
      no_peaks <- TRUE
    } else {
      data_clean <- data_clean[-dist_peaks[1:length(dist_peaks)],]
    }
  }
  if(i == 1){indi_subset_clean <- list(data_clean)
  }else{indi_subset_clean[i] <- list(data_clean)
  }
  indi_subset_clean[[i]]$peak <- 0
  indi_subset_clean[[i]]$peak[
     which(is.na(indi_subset_clean[[i]]$dist_m) == FALSE &
        indi_subset_clean[[i]]$dist_m >= max_dist_m)] <- 1
}

#Recalculate start/stop times
start_dt <- st_times(indi_subset_clean)[[1]]
stop_dt <- st_times(indi_subset_clean)[[2]]

#Interpolate tracks
for(i in 1:length(indi_subset_clean)){
  out_n <- as.integer(difftime(stop_dt[i],start_dt[i],units="mins"))+1
  coords <- matrix(c(indi_subset_clean[[i]]$lon,indi_subset_clean[[i]]$lat),
     nrow=length(indi_subset_clean[[i]]$lon))
  lon_inter <- approx(coords[,1], n = out_n)
  lat_inter <- approx(coords[,2], n = out_n)
  dt_new <- seq(indi_subset_clean[[i]]$dt[1],
     indi_subset_clean[[i]]$dt[length(indi_subset_clean[[i]]$dt)], length.out = out_n)

  pop_name <- as.character(dt_new)
  pop_name[1:length(pop_name)] <- as.character(indi_subset_clean[[i]]$population[1])
  indi_name <- as.character(dt_new)
  indi_name[1:length(indi_name)] <- as.character(indi_subset_clean[[i]]$individual[1])
  if(i==1){
   indi_subset_int <- list(data.frame(lon_inter$y,lat_inter$y,pop_name,indi_name,dt_new))
    colnames(indi_subset_int[[i]]) <- c("lon","lat","population","individual","dt")
```

```
  }else{
   indi_subset_int[i] <- list(data.frame(lon_inter$y,lat_inter$y,pop_name,indi_name,dt_new))
    colnames(indi_subset_int[[i]]) <- c("lon","lat","population","individual","dt")
  }
  indi_subset_int[[i]] <- calc_dist(indi_subset_int[[i]])
}

#Segmentate moving/resting
resting_rad <- 20 #meters/min
for(i in 1:length(indi_subset_int)){
  if(i == 1){
    indi_subset_class <- list(class_moving(indi_subset_int[[i]],resting_rad))
  }else{
    indi_subset_class[i] <- list(class_moving(indi_subset_int[[i]],resting_rad))
  }
}

#Removing non-moving time periods...
for(i in 1:length(indi_subset_class)){
  if(i == 1){indi_subset_moving <- list(
     indi_subset_class[[i]][which(indi_subset_class[[i]]$moving == 1),])}
  else{indi_subset_moving[i] <- list(
     indi_subset_class[[i]][which(indi_subset_class[[i]]$moving == 1),])}
}

#Extract names of each individual
for(i in 1:length(indi_subset_moving)){
  if(length(indi_subset_moving[[i]][,1]) > 0){
    if(i==1){
      indi_names <- indi_subset_moving[[i]]$individual[1]
    }else{
      indi_names <- paste0(indi_names,", ",indi_subset_moving[[i]]$individual[1])
    }
  }
}

#Create move objects list
move_index <- 0
for(i in 1:length(indi_subset_moving)){
  maxi <- length(indi_subset_moving[[i]]$lon)
  #maxi <- 200 #If the maximum length should be defined by the user
  #if(length(indi_subset_moving[[i]]$lon) < maxi){
     maxi <- length(indi_subset_moving[[i]]$lon)
  }

  if(length(indi_subset_moving[[i]][,1]) > 0){
    if(i == 1){data_ani <-
      list(move(x=indi_subset_moving[[i]]$lon[1:maxi],y=indi_subset_moving[[i]]$lat[1:maxi],
          time=indi_subset_moving[[i]]$dt[1:maxi],proj=CRS("+proj=longlat +ellps=WGS84"),
           animal=unlist(strsplit(indi_names,", "))[i]))
    }else{data_ani[i-move_index] <-
      list(move(x=indi_subset_moving[[i]]$lon[1:maxi],y=indi_subset_moving[[i]]$lat[1:maxi],
          time=indi_subset_moving[[i]]$dt[1:maxi],proj=CRS("+proj=longlat +ellps=WGS84"),
```

```
        animal=unlist(strsplit(indi_names,", "))[i]))}
  }else{move_index <- move_index+1}
}

#write out
file.create("moveVis_sample.txt")
for(i in 1:length(indi_subset_moving)){
  print(i)
  if(i == 1){
    writethis <- indi_subset_moving[[i]]
    write.table(writethis,file="samples.txt",sep=";")
  }else{
    writethis <- rbind(writethis,indi_subset_moving[[i]])
    write.table(writethis,file="samples.txt",sep=";")
  }
}

## End(Not run)
```

Index