Travel Paths

Bridging the usability gap in open source animal movement algorithms

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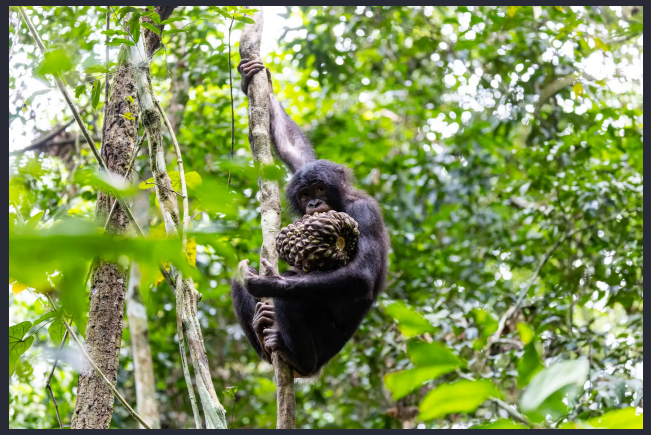
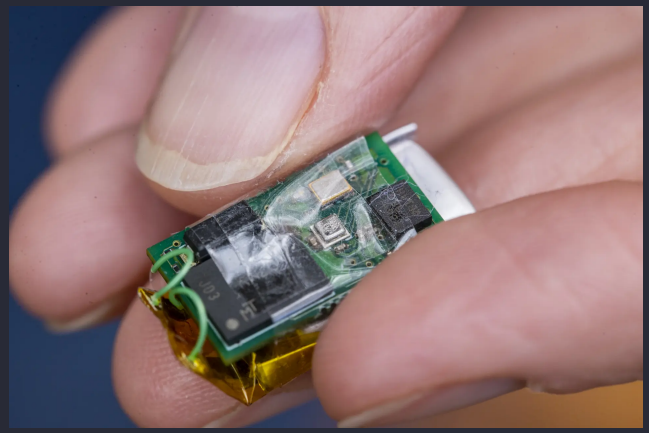
I help scientists with their data analysis at *Max Planck Institute of Animal Behavior*.

`travelpaths` package provides a consistent interface that simplifies the process of running multiple methods on an animal movement dataset.

Target End User

Researchers who collect movement data using both traditional and automated methods.





Typically R users with a passion for science not for coding. Much of the analysis is carried out by early career researchers.

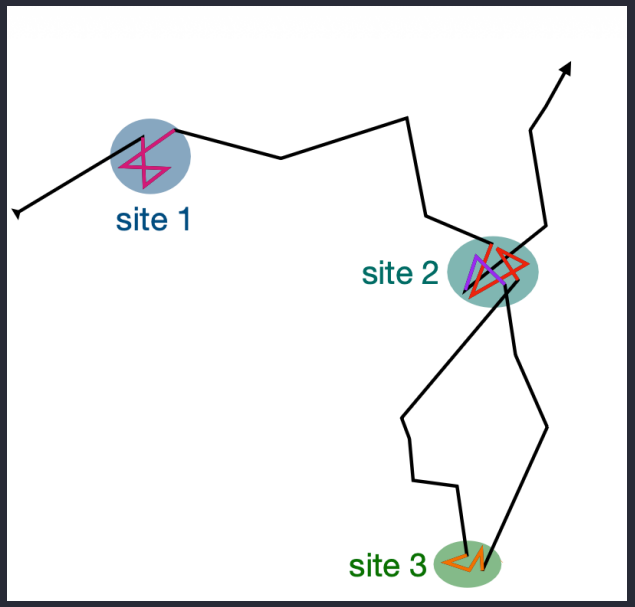
Scientific Scope

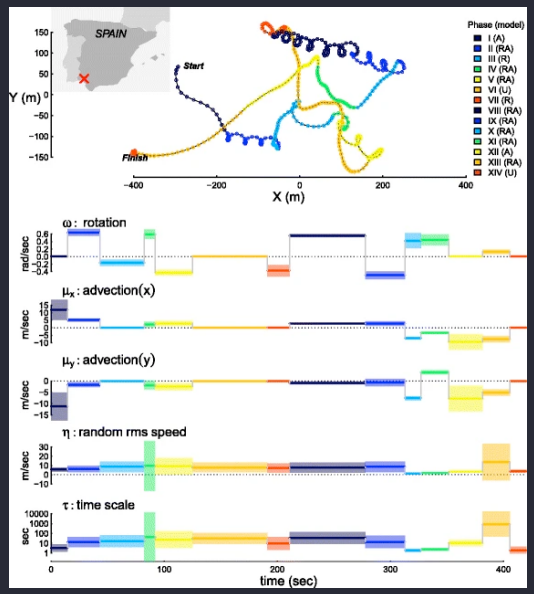
Animal Movement Data typically consists of x, y, time, and individual id.

Movement Classification is a diverse group of methodologies that break a longer movement path into distinct sections, and optionally group those section.

This step is performed to understand a variety of biologically significant characteristics including but not limited to

- Key locations
- Activity state
- Overall direction of travel





Gurarie et al. 2017

The Opportunity

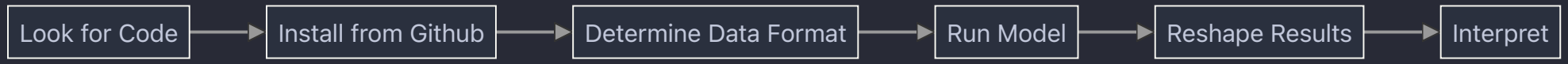
Lots of peer-reviewed methods to classify an animal path into segments of interest and group those segments.

The Problem

Takes time to learn how to implement each method. Each user has to dig into each method one by one.

Method 1

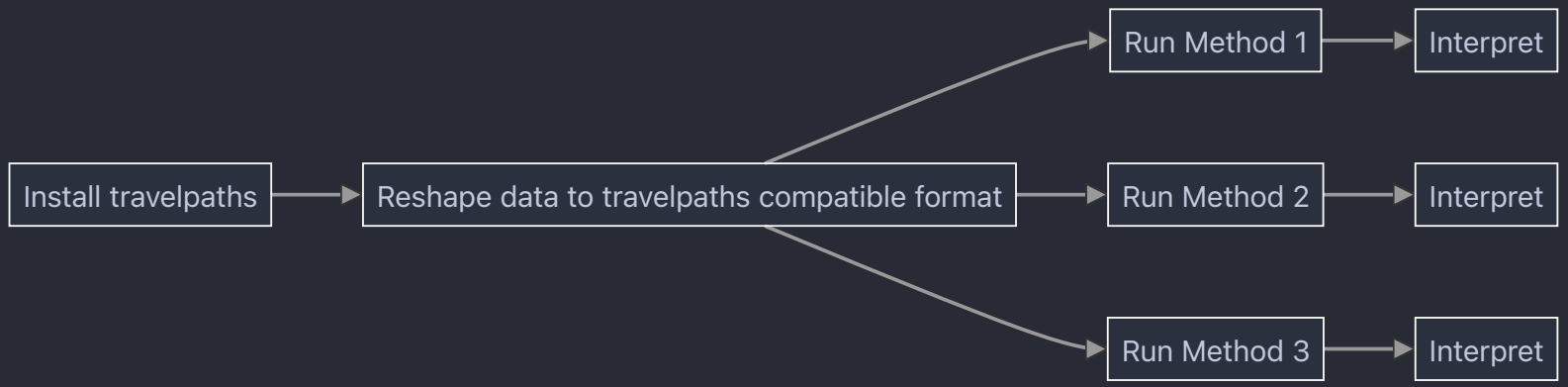
Method 2



Method 3

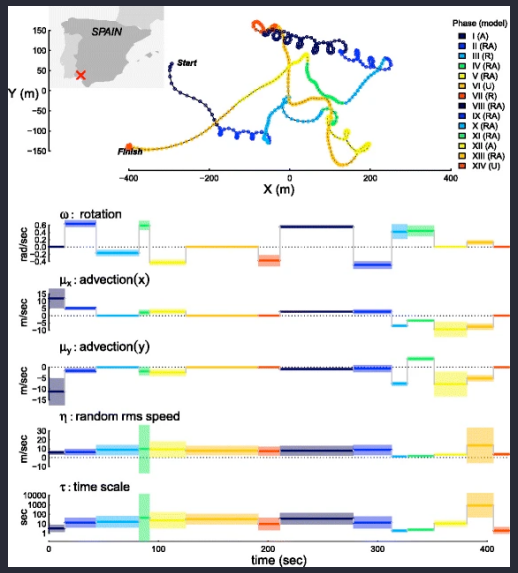
The Solution

`travelpaths` contributer integrates each method **one time**

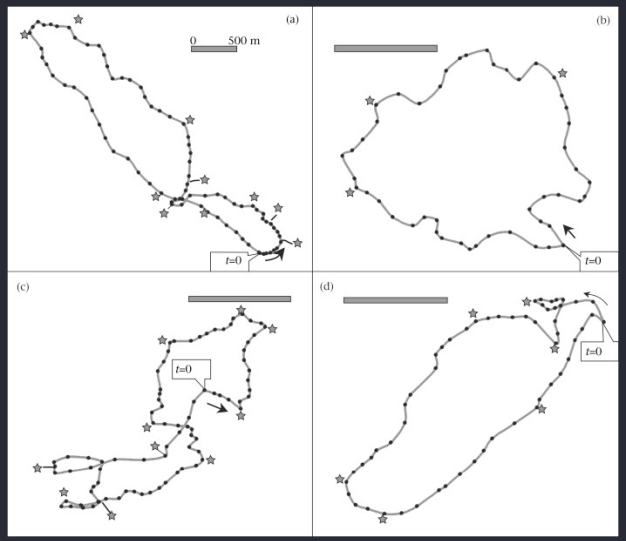


Example: CVM, CPT

Two (of many) ways to identify change points in animal movement data



"Correlated Velocity Models" aka CVM Explicitly models speed and direction changes. Can be used to identify change points ie points where the best model changes. *Gurarie et al. 2017*

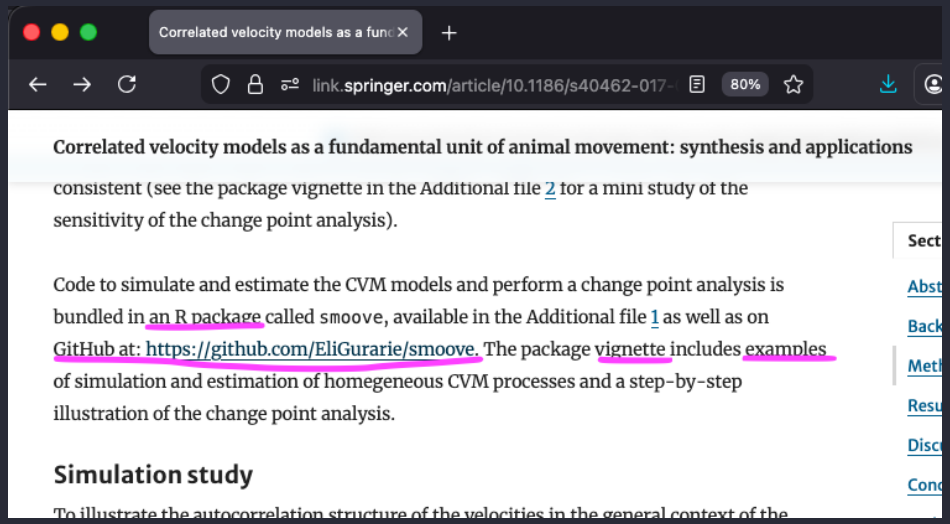


"Change Point Test" aka CPT Uses permutation test based approach to identify changes in direction. *Byrne et al. 2009*

Finding code (without `travelpaths`)

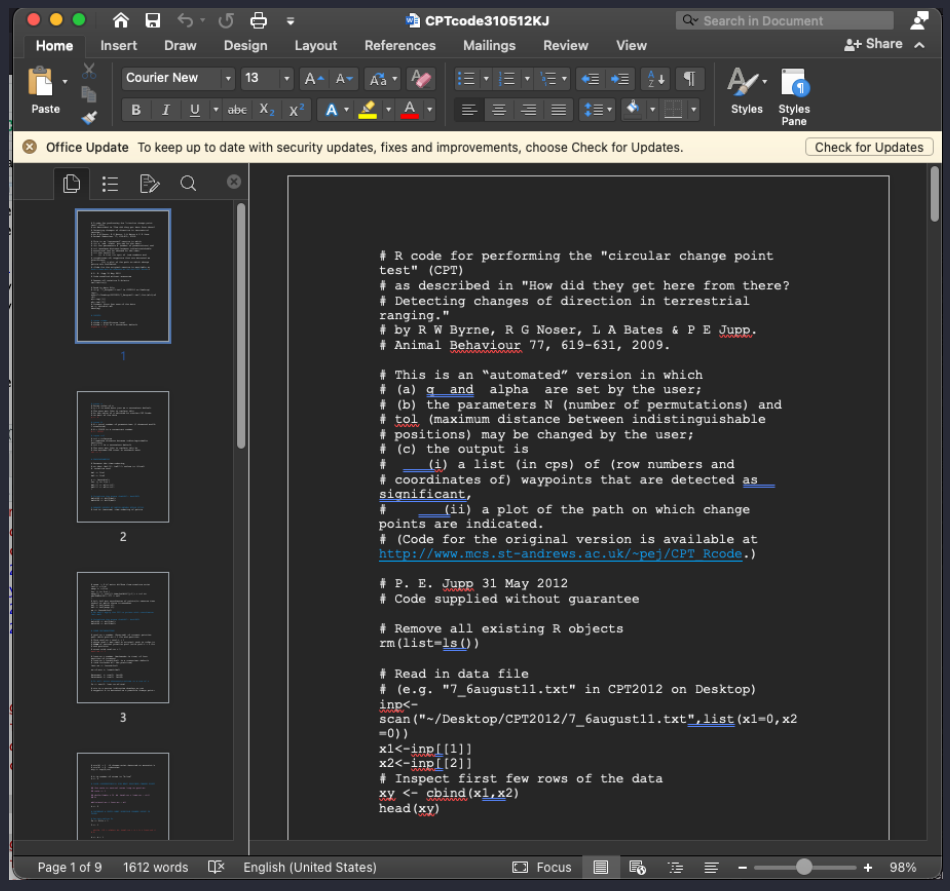
Best Case Scenario (CVM)

- Direct (working!) link from paper to code



Mid Case Scenario (CPT)

- Broken link to in paper
- Author was responsive via email



Reshaping for Input (without `trackframe`)

CVM

> Z location data. Can be: a complex vector, a two-column matrix or data frame, an ltraj object from adehabitatLT or a move object from the move package.
>
> T time vector, ignored if Z is an ltraj or move

Note: move not move2

CPT

[not documented]

two column *data.frame* of coordinates

Running the Methods (without `travelpaths`)

CVM

```
cvm_result <- sweepRACVM(
  Z = my_data[, "utm.easting", "utm.northing"],
  T = my_data$timestamp,
  windowsize = 1000,
  windowstep = 50,
  model = 'UCVM'
) |>
  findCandidateChangePoints(clusterwidth = 4) |>
  getCPtable(modelset = 'UCVM', iterate = TRUE) |>
  estimatePhases()
```

CPT

Provided as a script, rather than as functions.

Using Output (without `trackframe`)

CVM

- Each row represents a segment between change points.
- `start` and `end` indicate the change points in *time*
- Extra step to apply back to the input data

	phase	start	end	model	eta	tau	rms
1	I	2015-12-15 23:18:00	2016-01-15 05:36:00	UCVM	434.1731	1.034823e-40	434.1731
2	II	2016-01-15 05:36:00	2016-02-01 01:10:00	UCVM	379.6684	2.438886e-39	379.6684
3	III	2016-02-01 01:10:00	2016-02-26 03:40:00	UCVM	365.9379	7.802973e-29	365.9379
4	IV	2016-02-26 03:40:00	2016-02-28 03:44:00	UCVM	346.7161	8.921303e-36	346.7161
5	V	2016-02-28 03:44:00	2016-04-01 03:12:00	UCVM	399.3652	1.112064e-32	399.3652

CPT

- Results in a vector of *indices* of start and end of each segment

```
> start
[1]   6  52 189 222 282 419 440 470 516 692 731 755 876 887 889
```

Existing Tools

Method authors' design choices are not inherently bad.

However, inconsistancy among designs results in a system that takes work to navigate.

Running the Methods with `travelpaths`

Similar to `parsnip`, user

- defines the model
- runs `fit(model, data)`.

```
library(travelpaths)

data <- move2::movebank_download_study(...)
```

CVM

```
cvm_fit <- fit(
  cvm_change_points(method = "zLike"),
  data
)
```

CPT

```
cpt_fit <- fit(
  change_point_permtest(),
  data
)
```

Framework is extensiable.

Logic Written in One Style

Fit functions:

- support several commonly use input formats
  - sf-based and non-sf-based
  - base R data frame, tibble, data table
- logic built once
- return the format the user provided

Enabled by trackframe package.

```
1 library(trackframe)
2
3 mean_location <- function(data) {
4   tf <- as.trackframe(data)
5   tf$x_mean <- mean(easting(tf))
6   tf$y_mean <- mean(northing(tf))
```

```
7     return(tf_backtransform(tf))
8   }
```

Unified Output Format

CVM

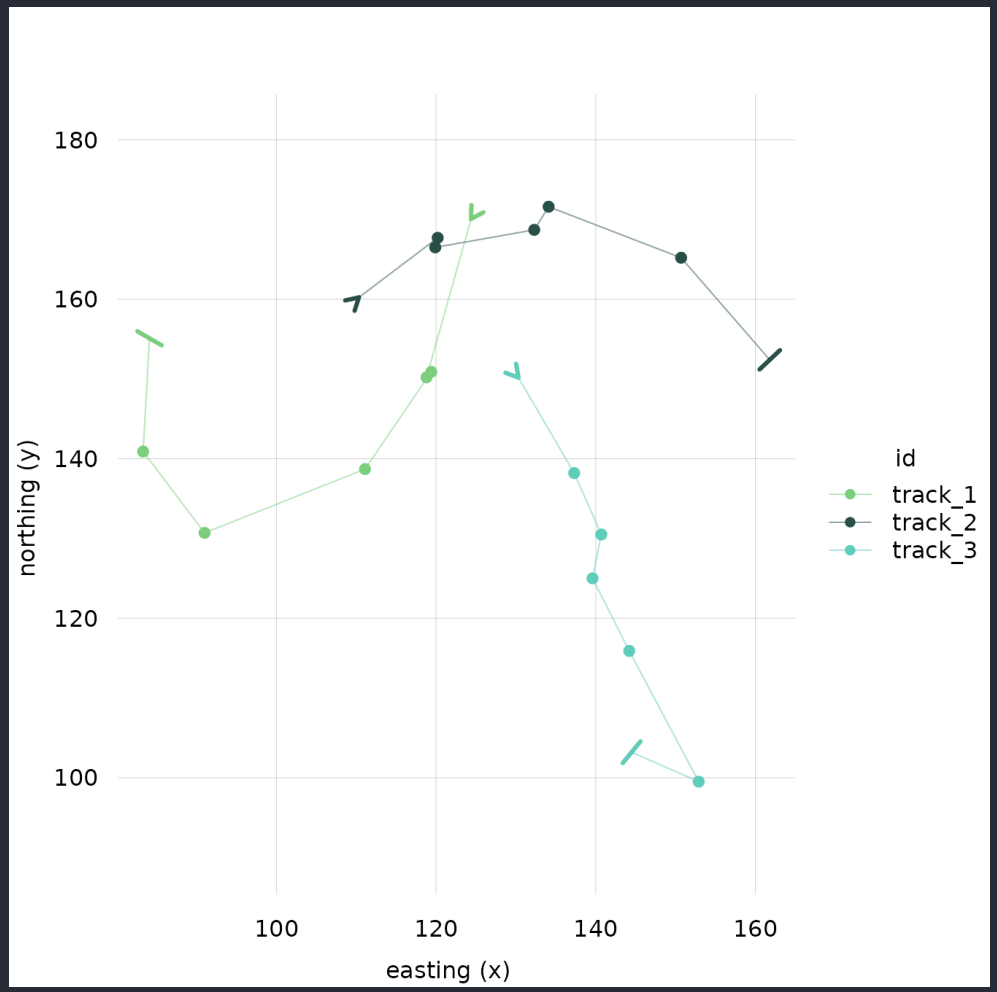
```
>cvm_fit$fit
A <move2> with `track_id_column` "id" and `time_column` "time"
Containing 1 track lasting 2.73 days in a
Simple feature collection with 1000 features and 3 fields
Geometry type: POINT
Dimension:     XY
Bounding box:  xmin: -0.009335803 ymin: -0.002704142 xmax: 0.001792057 ymax: 0.02229348
Projected CRS: WGS 84 / UTM zone 32N
First 10 features:
                  time      id cvm_model                       geometry
```

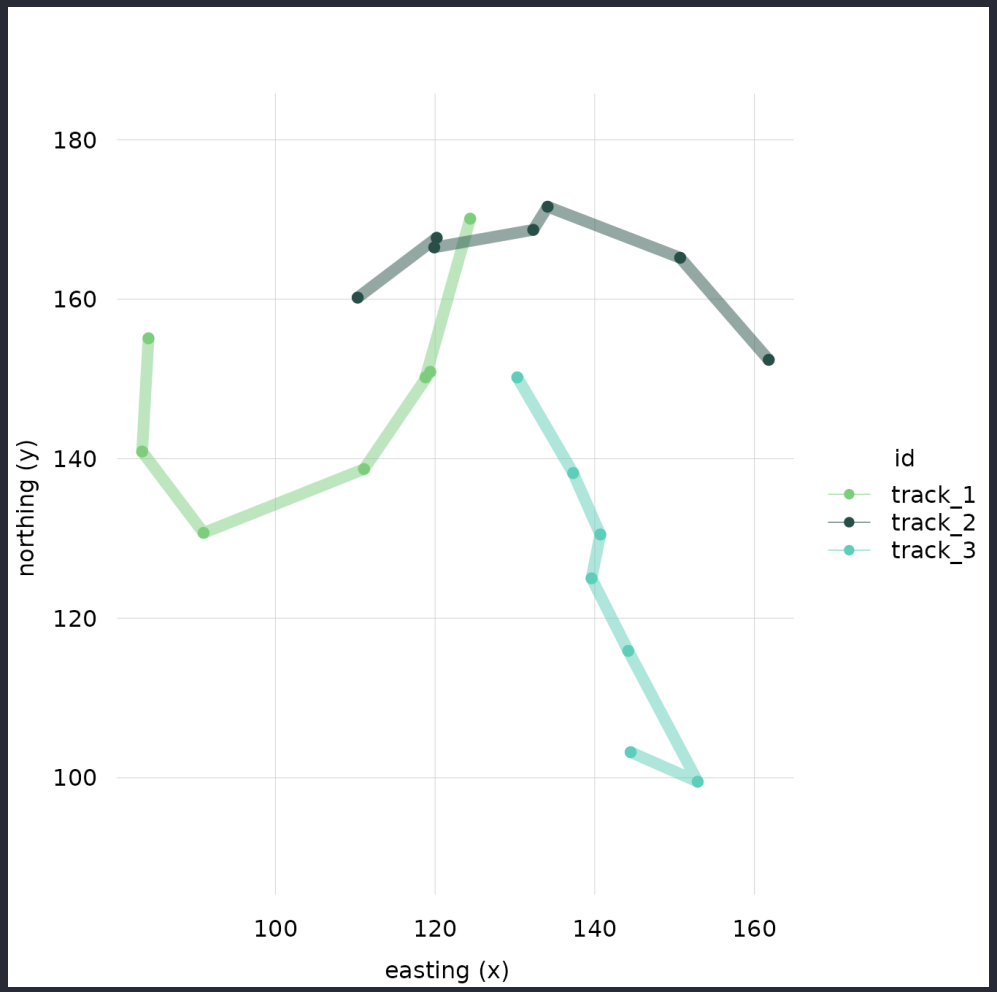
CPT

```
>cpt_fit$fit
A <move2> with `track_id_column` "id" and `time_column` "time"
Containing 1 track lasting 2.73 days in a
Simple feature collection with 1000 features and 3 fields
Geometry type: POINT
Dimension:     XY
Bounding box:  xmin: -0.009335803 ymin: -0.002704142 xmax: 0.001792057 ymax: 0.02229348
Projected CRS: WGS 84 / UTM zone 32N
First 10 features:
                  time      id cpt_segment                       geometry
```

`cvm_model`, `cpt_segment` columns identify which segment each data point is part of.

Customizable Plotting Functionality





Based on `tinyplot` therefore `tinyplot` themes can be applied.

Project Status

- `trackframe` stable version on github
  - github.com/livingingroups/trackframe
- `travelpaths` stablizing, will support three methods at launch
  - github.com/livingingroups/travelpaths

Plan to submit to CRAN by the end of the summer.

Where do we go from here?

- Extend to more methods
- Advanced plotting
- Model comparison functionality

Longer Term: Set the standard for Movement Ecology modeling interface.

Team

Collaboration between Max Planck Institute of Animal Behavior and Quintik Technologies.

Dr. Alison Ashbury

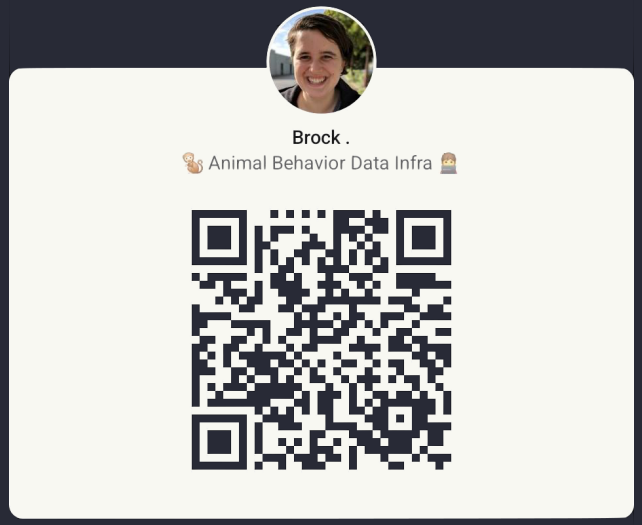
Dr. Rainer Hirk

Dr. Florian Schwendinger

Prof. Dr. Meg Crofoot

Special thanks to Dr. Peter Jupp and Dr. Eliezer Gurarie for prompt and thorough responses regarding CPT and CVM respectively.

Let's stay in touch



travelpaths

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Catch me on rOpenSci and Carpentries slack communities