

# Package ‘sleepr’

April 10, 2020

**Title** Analyse Activity and Sleep Behaviour

**Date** 2018-10-04

**Version** 0.3.0

**Description** Use behavioural variables to score activity and infer sleep from bouts of immobility.

It is primarily designed to score sleep in fruit flies from Drosophila Activity Monitor (TriKinetics) and Ethoscope data.

It implements sleep scoring using the “five-minute rule” (Hendricks et al. (2000) <DOI:10.1016/S0896-6273(00)80877-6>), activity classification for Ethoscopes (Geissmann et al. (2017) <DOI:10.1371/journal.pbio.2003026>) and a new algorithm to detect when animals are dead.

**Depends** R (>= 3.00),  
behavr

**Imports** data.table

**Suggests** testthat,  
covr,  
knitr

**License** GPL-3

**Encoding** UTF-8

**LazyData** true

**URL** <https://github.com/rethomics/sleepr>

**BugReports** <https://github.com/rethomics/sleepr/issues>

**RoxygenNote** 6.1.0

**Roxygen** list(markdown = TRUE)

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bout_analysis	<i>Find "bouts" in categorical time series</i>
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## Description

This function is used to find contiguous regions of unique value in a – potentially irregular/heterogeneous – univariate categorical time series.

## Usage

```
bout_analysis(var, data)
```

## Arguments

var	name of the variable to use from data
data	<a href="#">data.table</a> containing behavioural variable from or one multiple animals. When it has a key, unique values, are assumed to represent unique individuals (e.g. in a <a href="#">behavr</a> table). Otherwise, it analysis the data as coming from a single animal. data must have a column t representing time.

## Value

an object of the same type as data (i.e. [data.table::data.table](#) or [behavr::behavr](#)). Each row is a specific bout characterised by three columns.

- t – its *onset*
- duration – its length
- <var> – a column with the same name as var. The value of var for this bout.

## References

- The relevant [rethomic tutorial section](#) – on sleep analysis

## See Also

- [sleep\\_annotation](#) – to generate a binary sleep variable
- [rle](#) run length encoding function – on which this analysis is based

## Examples

```
# Bout analysis on binary variable:
dt <- toy_dam_data()
dt[, moving := activity > 0]
bdt <- bout_analysis(moving, dt)
print(bdt)
# With multiple states
dt <- toy_ethoscope_data()
# we discretise x position in three states: left, middle and right (1/3 each)
dt[, location := as.character( cut(x,
                                breaks = c(0.0, .33, .67, 1.0),
                                labels = c("left", "middle", "right")))]

bdt <- bout_analysis(location, dt)
```

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curate_dead_animals	<i>Remove – irrelevant – data after individual have died</i>
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## Description

This function detects when individuals have died based on their first (very) long bout of immobility. Following data (which may include spurious artefact of movement) are removed.

## Usage

```
curate_dead_animals(data, moving_var = moving, time_window = hours(24),
  prop_immobile = 0.01, resolution = 24)
```

## Arguments

data	<a href="#">data.table</a> containing behavioural variable from or one multiple animals. When it has a key, unique values, are assumed to represent unique individuals (e.g. in a <a href="#">behavr</a> table). Otherwise, it analysis the data as coming from a single animal. data must have a column t representing time.
moving_var	logical variable in data used to define the moving (alive) state (default is moving)
time_window	window during which to define death (default is one day)
prop_immobile	proportion of immobility that counts as "dead" during time_window (see details)
resolution	how much scanning windows overlap. Expressed as a factor (see details).

## Details

This function scans the time series looking for "death" in the right (future) data, within time\_window. Death is defined as  $\text{mean}(\text{moving\_var}) < \text{prop\_immobile}$  within a time window. Moving window start every time\_window/resolution. resolution = 1 is fast but means no overlap. The default would score an animal as dead it does not move more than *one percent of the time* for at least *one day*. All data following a "death" event are removed.

**Value**

an object of the same type as data (i.e. `data.table::data.table` or `behavr::behavr`).

**See Also**

- [sleep\\_annotation](#) – to score movement and slepe

**Examples**

```
dt1 <- toy_activity_data()
#all movement after day 3 is set at 0
dt1[t > days(3), moving := FALSE]
# one artefact of movement is detected at day 3.5
dt1[t == days(3.5), moving := TRUE]

dt2 <- curate_dead_animals(dt1)
dt3 <- curate_dead_animals(dt1,prop_immobile = 0)
## Not run:
library(ggplot2)
ggplot(data=dt1[,test:=1],aes(t, as.numeric(moving))) +
  geom_line(data=dt1[,test:=1]) +
  geom_line(data=dt2[, test:=2])+
  geom_line(data=dt3[, test:=3])+
  facet_grid(test ~ .)+
  scale_x_time()

## End(Not run)
```

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motion\_detectors

*Motion detector for Ethocope data*

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**Description**

Defines whether a *single animal* is moving according to:

**Usage**

```
max_velocity_detector(data, time_window_length,
  velocity_correction_coef = 0.003, masking_duration = 6)

max_velocity_detector_legacy(data, velocity_threshold = 0.006)

virtual_beam_cross_detector(data, time_window_length)
```

## Arguments

data	<a href="#">data.table::data.table</a> containing behavioural variables of <i>a single animal</i> (no id). It must have the columns xy_dist_log10x1000(for computing subpixel velocity), x(beam cross), t and has_interacted (whether a stimulus was delivered).
time_window_length	number of seconds to be used by the motion classifier. This corresponds to the sampling period of the output data.
velocity_correction_coef	an empirical coefficient to correct velocity with respect to variable framerate.
masking_duration	number of seconds during which any movement is ignored (velocity is set to 0) after a stimulus is delivered (a.k.a. interaction).
velocity_threshold	uncorrected velocity above which an animal is classified as ‘moving’ (for the legacy version).

## Details

- Validated and corrected subpixel velocity ([max\\_velocity\\_detector](#)), the most rigorous
- Uncorrected subpixel velocity ([max\\_velocity\\_detector\\_legacy](#))
- Crossing a virtual beam in the middle of the region of interest ([virtual\\_beam\\_cross\\_detector](#))

[max\\_velocity\\_detector](#) is the default movement classification for real-time ethoscope experiments. It is benchmarked against human-generated ground truth.

These functions are *rarely called directly*, but typically used is in the context of [sleep\\_annotation](#).

## Value

an object of the same type as data (i.e. [data.table::data.table](#) or [behavr::behavr](#)) with additional columns:

- moving Logical, TRUE iff. motion was detected.
- beam\_crosses The number of beam crosses (when the animal crosses  $x = 0.5$  – that is the midpoint of the region of interest) within the time window
- max\_velocity The maximal velocity within the time window. The resulting data is sampled at a period equals to time\_window\_length.

## See Also

- [sleep\\_annotation](#) – which requires a motion detector

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sleep_annotation	<i>Score sleep behaviour from immobility</i>
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### Description

This function first uses a motion classifier to decide whether an animal is moving during a given time window. Then, it defines sleep as contiguous immobility for a minimum duration.

### Usage

```
sleep_annotation(data, time_window_length = 10,
  min_time_immobile = 300, motion_detector_FUN = max_velocity_detector,
  ...)
```

```
sleep_dam_annotation(data, min_time_immobile = 300)
```

### Arguments

data	<a href="#">data.table</a> containing behavioural variable from or one multiple animals. When it has a key, unique values, are assumed to represent unique individuals (e.g. in a <a href="#">behavr</a> table). Otherwise, it analysis the data as coming from a single animal. data must have a column t representing time.
time_window_length	number of seconds to be used by the motion classifier. This corresponds to the sampling period of the output data.
min_time_immobile	Minimal duration (in s) of a sleep bout. Immobility bouts longer or equal to this value are considered as sleep.
motion_detector_FUN	function used to classify movement
...	extra arguments to be passed to <code>motion_classifier_FUN</code> .

### Details

The default `time_window_length` is 300 seconds – it is also known as the "5-minute rule". `sleep_annotation` is typically used for ethoscope data, whilst `sleep_dam_annotation` only works on DAM2 data. These functions are *rarely used directly*, but rather passed as an argument to a data loading function, so that analysis can be performed on the go.

### Value

a [behavr](#) table similar to data with additional variables/annotations (i.e. moving and asleep). The resulting data will only have one data point every `time_window_length` seconds.

### References

- The relevant [rethomic tutorial section](#) – on sleep analysis

**See Also**

- [motion\\_detectors](#) – options for the motion\_detector\_FUN argument
- [bout\\_analysis](#) – to further analyse sleep bouts in terms of onset and length

**Examples**

```
dt_one_animal <- toy_ethoscope_data(seed=2)
##### Ethoscope, corrected velocity classification #####
sleep_dt <- sleep_annotation(dt_one_animal, masking_duration=0)
print(sleep_dt)
# We could make a sleep 'barcode'
## Not run:
library(ggplot2)
ggplot(sleep_dt, aes(t,y="Animal 1",fill=asleep)) +
  geom_tile() + scale_x_time()

## End(Not run)
##### Ethoscope, virtual beam cross classification #####
sleep_dt2 <- sleep_annotation(dt_one_animal,
  motion_detector_FUN=virtual_beam_cross_detector)

## Not run:
library(ggplot2)
ggplot(sleep_dt2, aes(t,y="Animal 1",fill=asleep)) +
  geom_tile() + scale_x_time()

## End(Not run)
##### DAM data, de facto beam cross classification #####
dt_one_animal <- toy_dam_data(seed=7)
sleep_dt <- sleep_dam_annotation(dt_one_animal)
## Not run:
library(ggplot2)
ggplot(sleep_dt, aes(t,y="Animal 1",fill=asleep)) +
  geom_tile() + scale_x_time()

## End(Not run)
```

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