Package 'baRulho'

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Type Package

Title Quantifying habitat-induced acoustic signal degradation

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Description Quantifying habitat-induced degradation of (animal) acoustic signals.

License GPL (>= 2)

Imports pbapply, warbleR, utils, stats, seewave, tuneR

Depends R (>= 3.2.1)

LazyData TRUE

URL https://github.com/maRce10/baRulho

BugReports https://github.com/maRce10/baRulho/issues

NeedsCompilation no

Suggests

RoxygenNote 7.0.2

Repository CRAN

Language en-US

R topics documented:

`atmospheric_attenuation` *Measure atmospheric attenuation and absorption of sound*

Description

`atmospheric_attenuation` measures atmospheric attenuation and atmospheric absorption of signals referenced in an extended selection table.

Usage

```
atmospheric_attenuation(f, temp, RH, p = 101325,
formula = 1, spi = NULL, dist = NULL)
```

Arguments

`f`	numeric vector of length 1 with frequency (in Hertz).
`temp`	numeric vector of length 1 with frequency (in Celsius).
`RH`	numeric vector of length 1 with relative humidity
`p`	numeric vector of length 1 with ambient pressure in Pa (standard: 101325, default).
`formula`	1 = Bazley 1976 (used by Marc), 2 = Rossing 2007 (p. 116, see details).
`spi`	numeric vector of length 1 with the initial sound pressure in Pa. Required for calculating atmospheric absorption. Default is `NULL`.
`dist`	numeric vector of length 1 with distance (m) over which a sound propagates. Required for calculating atmospheric absorption. Default is `NULL`.

Details

Calculate the atmospheric attenuation based on temperature, relative humidity, pressure and sound frequency. The function can applied to formulae based on:

- `1`: default. As used by Marc: Bazley (1976), Sound absorption in air at frequencies up to 100 kHz. NPL acoustics report Ac 74.
- `2`: as used by Peter: Rossing (2007), Handbook of Acoustics, Springer.

If 'spi' and 'dist' are supplied the function also returns the atmospheric absorption (in dB).

Value

Returns atmospheric attenuation (in dB/m) of sound based on supplied parameters. If 'spi' and 'dist' are supplied the function also returns atmospheric absorption (in dB).

Author(s)

Marcelo Araya-Salas (<marceloa27@gmail.com>)

References

Araya-Salas, M. (2019), baRulho: a R package to quantify habitat-induced degradation of (animal) acoustic signals. R package version 1.0.0

Examples

```
{
# load example data
data("playback_est")

#' # remove noise selections
playback_est <- playback_est[playback_est$signal.id != "noise", ]

# measure atmospheric attenuation formula 1
atmospheric_attenuation(f = 20000, temp = 20, RH = 90, p = 88000, formula = 1)
}
```

---

baRulho *baRulho: quantifying habitat-induced acoustic signal degradation*

Description

'baRulho' is a package intended to quantify habitat-induced degradation of (animal) acoustic signals.

Details

The main features of the package are:

- Loops to apply tasks through acoustic signals referenced in an extended selection table
- The comparison of signals playbacked and re-recorded at different distances

Most functions allow the parallelization of tasks, which distributes the tasks among several processors to improve computational efficiency.

License: GPL (>= 2)

Author(s)

Marcelo Araya-Salas

Maintainer: Marcelo Araya-Salas (<marceloa27@gmail.com>)

blur_ratio *Measure blur ratio*

Description

blur_ratio measures blur ratio in signals referenced in an extended selection table.

Usage

```
blur_ratio(X, parallel = 1, pb = TRUE, method = 1,
 ssmooth = NULL, msmooth = NULL, output = "est")
```

Arguments

X	object of class 'selection_table', 'extended_selection_table' created by the function selection_table from the warbleR package.
parallel	Numeric vector of length 1. Controls whether parallel computing is applied by specifying the number of cores to be used. Default is 1 (i.e. no parallel computing).
pb	Logical argument to control if progress bar is shown. Default is TRUE.
method	Numeric vector of length 1 to indicate the 'experimental design' for measuring envelope correlation. Two methods are available: • 1: compare all signals with their counterpart that was recorded at the closest distance to source (e.g. compare a signal recorded at 5m, 10m and 15m with its counterpart recorded at 1m). This is the default method. • 2: compare all signals with their counterpart recorded at the distance immediately before (e.g. a signal recorded at 10m compared with the same signal recorded at 5m, then signal recorded at 15m compared with same signal recorded at 10m and so on).
ssmooth	Numeric vector of length 1 determining the length of the sliding window used for a sum smooth for amplitude envelope calculation (used internally by env).
msmooth	Numeric vector of length 2 to smooth the amplitude envelope with a mean sliding window for amplitude envelope calculation. The first element is the window length (in number of amplitude values) and the second one the window overlap (used internally by env).
output	Character vector of length 1 to determine if an extended selection table ('est') or a data frame ('data.frame') is returned.

Details

Blur ratio measures the degradation of sound as a function of the change in signal energy in the time domain as described by Dabelsteen et al (1993). Blur ratio is measured as the ratio of the amplitude (amplitude envelope root mean square) of the reference signal to the re-recorded signal. The function measures the blur ratio on signals in which a reference playback has been re-recorded at different distances. The function compare each signal type to the corresponding reference signal.

The 'signal.id' column must be used to tell the function to only compare signals belonging to the same category (e.g. song-types). Two methods for calculating blur-ratio are provided

Value

Data frame similar to input data, but also includes a new column (blur.ratio) with the blur ratio values.

Author(s)

Marcelo Araya-Salas (<marceloa27@gmail.com>) #' @references Dabelsteen, T., Larsen, O. N., & Pedersen, S. B. (1993). Habitat-induced degradation of sound signals: Quantifying the effects of communication sounds and bird location on blur ratio, excess attenuation, and signal-to-noise ratio in blackbird song. The Journal of the Acoustical Society of America, 93(4), 2206.

Araya-Salas, M. (2019), baRulho: a R package to quantify habitat-induced degradation of (animal) acoustic signals. R package version 1.0.0

Examples

```
{
# load example data
data("playback_est")

# remove noise selections
playback_est <- playback_est[playback_est$signal.id != "noise", ]

# using method 1
blur_ratio(X = playback_est)

# using method 2
blur_ratio(X = playback_est, method = 2)
}
```

---

envelope_correlation *Measure amplitude envelope correlation*

Description

envelope_correlation measures amplitude envelope correlation of signals referenced in an extended selection table.

Usage

```
envelope_correlation(X, parallel = 1, pb = TRUE, method = 1, cor.method = "pearson",
ssmooth = NULL, msmooth = NULL, output = "est")
```

Arguments

X	object of class 'selection_table', 'extended_selection_table' created by the function selection_table from the warbleR package.
parallel	Numeric vector of length 1. Controls whether parallel computing is applied by specifying the number of cores to be used. Default is 1 (i.e. no parallel computing). If NULL (default) then the current working directory is used.
pb	Logical argument to control if progress bar is shown. Default is TRUE.
method	Numeric vector of length 1 to indicate the 'experimental design' to measure amplitude envelope correlation. Two methods are available: • 1: compare all signals with their counterpart that was recorded at the closest distance to source (e.g. compare a signal recorded at 5m, 10m and 15m with its counterpart recorded at 1m). This is the default method. • 2: compare all signals with their counterpart recorded at the distance immediately before (e.g. a signal recorded at 10m compared with the same signal recorded at 5m, then signal recorded at 15m compared with same signal recorded at 10m and so on).
cor.method	Character string indicating the correlation coefficient to be applied ("pearson", "spearman", or "kendall", see cor).
ssmooth	Numeric vector of length 1 to determine the length of the sliding window used for a sum smooth for amplitude envelope calculation (used internally by env).
msmooth	Numeric vector of length 2 to smooth the amplitude envelope with a mean sliding window for amplitude envelope calculation. The first element is the window length (in number of amplitude values) and the second one the window overlap (used internally by env).
output	Character vector of length 1 to determine if an extended selection table ('est', default) or a data frame ('data.frame') is returned.

Details

Amplitude envelope correlation measures the similarity of 2 signals in the time domain. The function measures the envelope correlation coefficients of signals in which a reference playback has been re-recorded at increasing distances. Values range from 1 (identical amplitude envelope, i.e. no degradation) to 0. The 'signal.id' column must be used to indicate the function to only compare signals belonging to the same category (e.g. song-types). The function will then compare each signal type to the corresponding reference signal. If signals differ in duration the shortest signal is slided over the longest and the highest correlation is returned. Two methods for calculating envelope correlation are provided (see 'method' argument).

Value

Data frame or extended selection table (depending on 'output' argument) similar to input data, but also includes a new column ('envelope.correlation') with the calculated amplitude envelope correlation coefficients.

Author(s)

Marcelo Araya-Salas (<marceloa27@gmail.com>)

References

Araya-Salas, M. (2019), baRulho: a R package to quantify habitat-induced degradation of (animal) acoustic signals. R package version 1.0.0

Apol, C.A., Sturdy, C.B. & Proppe, D.S. (2017). Seasonal variability in habitat structure may have shaped acoustic signals and repertoires in the black-capped and boreal chickadees. Evol Ecol. 32:57-74.

Examples

```
{
# load example data
data("playback_est")

# remove noise selections
playback_est <- playback_est[playback_est$signal.id != "noise", ]

# method 1
envelope_correlation(X = playback_est)

# method 2
envelope_correlation(X = playback_est, method = 2)
}
```

`excess_attenuation` *Measure excess attenuation*

Description

`excess_attenuation` measures excess attenuation in signals referenced in an extended selection table.

Usage

```
excess_attenuation(X, parallel = 1, pb = TRUE, method = 1,
bp = NULL, wl = 10, output = "est")
```

Arguments

`X`	object of class 'selection_table', 'extended_selection_table' created by the function `selection_table` from the warbleR package.
`parallel`	Numeric vector of length 1. Controls whether parallel computing is applied by specifying the number of cores to be used. Default is 1 (i.e. no parallel computing).
`pb`	Logical argument to control if progress bar is shown. Default is `TRUE`.
`method`	Numeric vector of length 1 to indicate the 'experimental design' for measuring excess attenuation. Two methods are available:

- 1: compare all signals with their counterpart that was recorded at the closest distance to source (e.g. compare a signal recorded at 5m, 10m and 15m with its counterpart recorded at 1m). This is the default method.
- 2: compare all signals with their counterpart recorded at the distance immediately before (e.g. a signal recorded at 10m compared with the same signal recorded at 5m, then signal recorded at 15m compared with same signal recorded at 10m and so on).

`bp` Numeric vector of length 2 giving the lower and upper limits of a frequency bandpass filter (in kHz). Default is `NULL`.

`wl` A numeric vector of length 1 specifying the window length of the spectrogram for applying bandpass. Default is 10. Ignored if `bp = NULL`. Note that lower values will increase time resolution, which is more important for amplitude ratio calculations.

`output` Character vector of length 1 to determine if an extended selection table ('est', default) or a data frame ('data.frame') is returned.

Details

Excess attenuation is the amplitude loss of a sound in excess of that due to spherical spreading. With every doubling of distance, sounds attenuate with a 6 dB loss of amplitude (Morton, 1975; Marten & Marler, 1977). Any additional loss of amplitude results in excess attenuation, or energy loss in excess of that expected to occur with distance via spherical spreading due to atmospheric conditions or habitat (Wiley & Richards, 1978).

The goal of the function is to measure the excess attenuation on signals in which a reference playback has been re-recorded at increasing distances. The 'signal.id' column must be used to indicate which signals belonging to the same category (e.g. song-types). The function will then compare each signal type to the corresponding reference signal. Two methods for calculating excess attenuation are provided (see 'method' argument).

Value

Data frame or extended selection table (depending on 'output' argument) similar to input data, but also includes a new column (excess.attenuation) with the excess attenuation values.

Author(s)

Marcelo Araya-Salas (<marceloa27@gmail.com>) #' @references Araya-Salas, M. (2019), baRulho: a R package to quantify habitat-induced degradation of (animal) acoustic signals. R package version 1.0.0

Marten, K., & Marler, P. (1977). Sound transmission and its significance for animal vocalization. Behavioral ecology and sociobiology, 2(3), 271-290.

Morton, E. S. (1975). Ecological sources of selection on avian sounds. The American Naturalist, 109(965), 17-34.

Examples

```
{
# load example data
data("playback_est")

# remove noise selections
playback_est <- playback_est[playback_est$signal.id != "noise", ]

# using method 1
excess_attenuation(X = playback_est)

# using method 2
excess_attenuation(X = playback_est, method = 2)
}
```

`playback_est` *Extended selection table with re-recorded playbacks*

Description

Recordings of *Phaethornis longirostris* (Long-billed Hermit) songs from different song types (column 'signal.id') that were broadcast and re-recorded at 4 distances (1m, 5m, 10m, 15m, column 'distance'). The data includes ambient (background) noise selections for each distances. The data was created by the function `selection_table` from the warbleR package.

Usage

```
data(playback_est)
```

Format

Extended selection table object in the `warbleR` format, which contains annotations and acoustic data

Source

Marcelo Araya-Salas

snr_attenuation *Measure attenuation as signal-to-noise ratio*

Description

snr_attenuation measures attenuation as signal-to-noise ratio of signals referenced in an extended selection table.

Usage

```
snr_attenuation(X, mar, parallel = 1, pb = TRUE, eq.dur = FALSE,
noise.ref = "adjacent", type = 1, bp = NULL, wl = 10, output = "est")
```

Arguments

X	object of class 'selection_table', 'extended_selection_table' created by the function selection_table from the warbleR package.
mar	numeric vector of length 1. Specifies the margins adjacent to the start and end points of selection over which to measure noise.
parallel	Numeric vector of length 1. Controls whether parallel computing is applied by specifying the number of cores to be used. Default is 1 (i.e. no parallel computing).
pb	Logical argument to control if progress bar is shown. Default is TRUE.
eq.dur	Logical. Controls whether the noise segment that is measured has the same duration to that of the signal (if TRUE. Default is FALSE). If TRUE then 'mar' and 'noise.ref' arguments are ignored.
noise.ref	Character vector of length 1 to determined if a noise segment to be used for measuring ambient noise. Two options are available: • adjacent: measure ambient noise right before the signal (using argument 'mar' to define duration of noise segments). If several 'noise' selections by sound file are supplied, then the root mean square of the amplitude envelope will be averaged across those selections. • custom: measure noise segments referenced in the selection table (labeled as 'noise' in the 'signal.id' column). Those segments will be used to apply the same noise reference to all signals in a sound file. Therefore, at least one 'noise' selection for each sound file must be provided.
type	Numeric vector of length 1. Selects the formula to be used to calculate the signal-to-noise ratio (S = signal , N = background noise): • 1: ratio of S amplitude envelope root mean square to N amplitude envelope root mean square (rms(env(S))/rms(env(N))) • 2: ratio of the difference between S amplitude envelope root mean square and N amplitude envelope root mean square to N amplitude envelope root mean square ((rms(env(S)) - rms(env(N)))/rms(env(N)), as proposed by Dabelsteen et al (1993))

bp	Numeric vector of length 2 giving the lower and upper limits of a frequency bandpass filter (in kHz). Default is NULL.
wl	A numeric vector of length 1 specifying the window length of the spectrogram for applying bandpass. Default is 10. Ignored if bp = NULL. Note that lower values will increase time resolution, which is more important for amplitude ratio calculations.
output	Character vector of length 1 to determine if an extended selection table ('est', default) or a data frame ('data.frame') is returned.

Details

Signal-to-noise ratio measures signal amplitude level in relation to ambient noise. A general margin in which ambient noise will be measured must be specified. Alternatively, a selection of ambient noise can be used as reference (see 'noise.ref' argument). When margins overlap with another acoustic signal nearby, the signal-to-noise ratio (SNR) will be inaccurate, so margin length should be carefully considered. Any SNR less than or equal to one suggests background noise is equal to or overpowering the acoustic signal. The 'signal.id' column must be used to indicate which signals belong to the same category (e.g. song-types). The function will then compare each signal type to the corresponding reference signal. Two methods for calculating signal-to-noise ratio are provided (see 'type' argument).

Value

Data frame or extended selection table (depending on 'output' argument) similar to input data, but also includes a new column (snr.attenuation) with the signal-to-noise ratio values.

Author(s)

Marcelo Araya-Salas (<marceloa27@gmail.com>) #' @references Dabelsteen, T., Larsen, O. N., & Pedersen, S. B. (1993). Habitat-induced degradation of sound signals: Quantifying the effects of communication sounds and bird location on blur ratio, excess attenuation, and signal-to-noise ratio in blackbird song. The Journal of the Acoustical Society of America, 93(4), 2206.

Araya-Salas, M. (2019), baRulho: a R package to quantify habitat-induced degradation of (animal) acoustic signals. R package version 1.0.0

Examples

```
{
# load example data
data("playback_est")

# using noise reference selections
snr_attenuation(X = playback_est, mar = 0.05, noise.ref = 'custom')

#' # remove noise selections
playback_est <- playback_est[playback_est$signal.id != "noise", ]
# using margin for noise of 0.05 and adjacent noise reference
snr_attenuation(X = playback_est, mar = 0.05, noise.ref = 'adjacent')
}
```

`spectrum_correlation` *Measure frequency spectrum correlation*

Description

`spectrum_correlation` measures frequency spectrum correlation of signals referenced in an extended selection table.

Usage

```
spectrum_correlation(X, parallel = 1, pb = TRUE, method = 1, cor.method = "pearson",
output = "est")
```

Arguments

`X`	object of class 'selection_table', 'extended_selection_table' created by the function `selection_table` from the warbleR package.
`parallel`	Numeric vector of length 1. Controls whether parallel computing is applied by specifying the number of cores to be used. Default is 1 (i.e. no parallel computing). If `NULL` (default) then the current working directory is used.
`pb`	Logical argument to control if progress bar is shown. Default is `TRUE`.
`method`	Numeric vector of length 1 to indicate the 'experimental design' to measure frequency spectrum correlation. Two methods are available: • `1`: compare all signals with their counterpart that was recorded at the closest distance to source (e.g. compare a signal recorded at 5m, 10m and 15m with its counterpart recorded at 1m). This is the default method. • `2`: compare all signals with their counterpart recorded at the distance immediately before (e.g. a signal recorded at 10m compared with the same signal recorded at 5m, then signal recorded at 15m compared with same signal recorded at 10m and so on).
`cor.method`	Character string indicating the correlation coefficient to be applied ("pearson", "spearman", or "kendall", see `cor`).
`output`	Character vector of length 1 to determine if an extended selection table ('est', default) or a data frame ('data.frame') is returned.

Details

frequency spectrum correlation measures the similarity of 2 signals in the time domain. The function measures the spectrum correlation coefficients of signals in which a reference playback has been re-recorded at increasing distances. Values range from 1 (identical frequency spectrum, i.e. no degradation) to 0. The 'signal.id' column must be used to indicate the function to only compare signals belonging to the same category (e.g. song-types). The function will then compare each signal type to the corresponding reference signal. Two methods for calculating spectrum correlation are provided (see 'method' argument).

Value

Data frame or extended selection table (depending on 'output' argument) similar to input data, but also includes a new column ('spectrum.correlation') with the calculated frequency spectrum correlation coefficients.

Author(s)

Marcelo Araya-Salas (<marceloa27@gmail.com>)

References

Araya-Salas, M. (2019), baRulho: a R package to quantify habitat-induced degradation of (animal) acoustic signals. R package version 1.0.0

Apol, C.A., Sturdy, C.B. & Proppe, D.S. (2017). Seasonal variability in habitat structure may have shaped acoustic signals and repertoires in the black-capped and boreal chickadees. Evol Ecol. 32:57-74.

Examples

```
{
# load example data
data("playback_est")

# remove noise selections
playback_est <- playback_est[playback_est$signal.id != "noise", ]

# method 1
spectrum_correlation(X = playback_est)

# method 2
spectrum_correlation(X = playback_est, method = 2)
}
```

`xcorr_distortion` *Measure spectrographic cross-correlation as a measure of signal distortion*

Description

`xcorr_distortion` Measures spectrographic cross-correlation as a measure of signal distortion in signals referenced in an extended selection table.

Usage

```
xcorr_distortion(X = NULL, parallel = 1, pb = TRUE,  method = 1, cor.method = "pearson",
wl = 512, ovlp = 90, wn = 'hanning', output = "est")
```

Arguments

X	object of class 'selection_table', 'extended_selection_table' created by the function selection_table from the warbleR package.
parallel	Numeric vector of length 1. Controls whether parallel computing is applied by specifying the number of cores to be used. Default is 1 (i.e. no parallel computing).
pb	Logical argument to control if progress bar is shown. Default is TRUE.
method	Numeric vector of length 1 to indicate the 'experimental design' for measuring envelope correlation. Two methods are available: • 1: compare all signals with their counterpart that was recorded at the closest distance to source (e.g. compare a signal recorded at 5m, 10m and 15m with its counterpart recorded at 1m). This is the default method. • 2: compare all signals with their counterpart recorded at the distance immediately before (e.g. a signal recorded at 10m compared with the same signal recorded at 5m, then signal recorded at 15m compared with same signal recorded at 10m and so on).
cor.method	Character string indicating the correlation coefficient to be applied ("pearson", "spearman", or "kendall", see cor).
wl	A numeric vector of length 1 specifying the window length of the spectrogram, default is 512.
ovlp	Numeric vector of length 1 specifying % of overlap between two consecutive windows, as in spectro. Default is 90. High values of ovlp slow down the function but produce more accurate results.
wn	A character vector of length 1 specifying the window name as in ftwindow.
output	Character vector of length 1 to determine if an extended selection table ('est', default) or a data frame ('data.frame') is returned.

Details

The spectrographic cross-correlation measures frequency distortion of signals as a similarity metric where values range from 1 (completely equal, no distortion) and decays towards 0 (highly distorted). Cross-correlation is measured of signals in which a reference playback has been re-recorded at increasing distances. The 'signal.id' column must be used to indicate the function to only compare signals belonging to the same category (e.g. song-types). The function will then compare each signal type to the corresponding reference signal. Two methods for calculating cross-correlation are provided (see 'method' argument). The function is a wrapper on warbleR's xcorr function.

Value

Data frame or extended selection table (depending on 'output' argument) similar to input data, but includes a new column (cross.correlation) with the spectrogram cross-correlation coefficients.

Author(s)

Marcelo Araya-Salas (<marceloa27@gmail.com>)

References

Araya-Salas, M. (2019), baRulho: a R package to quantify habitat-induced degradation of (animal) acoustic signals. R package version 1.0.0

Clark, C.W., Marler, P. & Beeman K. (1987). Quantitative analysis of animal vocal phonology: an application to Swamp Sparrow song. Ethology. 76:101-115.

Examples

```
{
# load example data
data("playback_est")

# remove noise selections
playback_est <- playback_est[playback_est$signal.id != "noise", ]

# method 1
xcorr_distortion(X = playback_est, method = 1)

# method 2
xcorr_distortion(X = playback_est, method = 2)
}
```

Index