Package 'tuneR'

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Title Analysis of Music and Speech

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from Sebastian Krey, Olaf Mersmann, Sarah Schnackenberg, Guillaume Guenard,
Andrea Preusser, Anita Thieler, Johanna Mielke and Claus Weihs, as well as code fragments
and ideas from the former package 'sound' by Matthias Heymann
and functions from 'rastamat' by Daniel P. W. Ellis.
The included parts of the libmad MPEG audio decoder library are
authored by Underbit Technologies.

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Depends R (>= 3.0.0)

Suggests pastecs

Imports signal, methods

Description Analyze music and speech, extract features like MFCCs, handle wave files and their representation in various ways, read mp3, read midi, perform steps of a transcription, ...
Also contains functions ported from the 'rastamat' 'Matlab' package.

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NeedsCompilation yes

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R topics documented:

`Arith-methods` *Arithmetics on Waves*

Description

Methods for arithmetics on Wave and WaveMC objects

Methods

object = "Wave" An object of class `Wave`.

object = "WaveMC" An object of class `WaveMC`.

object = "numeric" For, e.g., adding a number to the whole Wave, e.g. useful for demeaning.

object = "missing" For unary Wave operations.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

For the S3 generic: `groupGeneric`, Wave-class, `Wave`, WaveMC-class, `WaveMC`

`audspec` *Frequency band conversion*

Description

Perform critical band analysis (see PLP), which means the reduction of the fourier frequencies of a signal's powerspectrum to a reduced number of frequency bands in an auditory frequency scale.

Usage

```
audspec(pspectrum, sr = 16000, nfilts = ceiling(hz2bark(sr/2)) + 1,
    fbtype = c("bark", "mel", "htkmel", "fcmel"), minfreq = 0,
    maxfreq = sr/2, sumpower = TRUE, bwidth = 1)
```

Arguments

pspectrum	Output of powspec, matrix with the powerspectrum of each time frame in its columns.
sr	Sample rate of the original recording.
nfilts	Number of filters/frequency bins in the auditory frequency scale.
fbtype	Used auditory frequency scale.
minfreq	Lowest frequency.
maxfreq	Highest frequency.
sumpower	If sumpower = TRUE, the frequency scale transformation is based on the power-spectrum, if sumpower = FALSE, it is based on its squareroot (absolute value of the spectrum) and squared afterwards.
bwidth	Modify the width of the frequency bands.

Value

aspectrum	Matrix with the auditory spectrum of each time frame in its columns.
wts	Weight matrix for the frequency band conversion.

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis: http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/

See Also

fft2melmx, fft2barkmx

Examples

```
testsound <- normalize(sine(400) + sine(1000) + square(250), "16")
pspectrum <- powspec(testsound@left, testsound@samp.rate)
aspectrum <- audspec(pspectrum, testsound@samp.rate)
```

bind *Concatenating Wave objects*

Description

Generic function for concatenating objects of class Wave or WaveMC.

Usage

```
bind(object, ...)
## S4 method for signature 'Wave'
bind(object, ...)
## S4 method for signature 'WaveMC'
bind(object, ...)
```

Arguments

object, ...	Objects of class Wave or class WaveMC, each of the same class and of the same kind (checked by equalWave), i.e. identical sampling rate, resolution (bit), and number of channels (for WaveMC, resp. stereo/mono for Wave).

Value

An object of class Wave or class WaveMC that corresponds to the class of the input.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg

See Also

prepComb for preparing the concatenation, Wave-class, Wave, WaveMC-class, WaveMC, extractWave, stereo

channel *Channel conversion for Wave objects*

Description

Convenient wrapper to extract one or more channels (or mirror channels) from an object of class Wave.

Usage

```
channel(object, which = c("both", "left", "right", "mirror"))
```

Arguments

object	Object of class Wave.
which	Character indicating which channel(s) should be returned.

Details

For objects of WaveMC-class, channel selection can be performed by simple matrix indexing, e.g. `WaveMCobject[,2]` selects the second channel.

Value

`Wave` object including channels specified by `which`.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

Wave, Wave-class, mono, extractWave

---

deltas *Calculate delta features*

Description

Calculate the deltas (derivatives) of a sequence of features using a w-point window with a simple linear slope.

Usage

```
deltas(x, w = 9)
```

Arguments

x	Matrix of features. Every column represents one time frame. Each row is filtered separately.
w	Window width (usually odd).

Details

This function mirrors the delta calculation performed in HTKs 'feacalc'.

Value

Returns a matrix of the delta features (one column per frame).

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis: http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/

Examples

```
testsound <- normalize(sine(400) + sine(1000) + square(250), "16")
m <- melfcc(testsound, frames_in_rows=FALSE)
d <- deltas(m)
```

---

dolpc *(Perceptive) Linear Prediction*

Description

Compute autoregressive model from spectral magnitude samples via Levinson-Durbin recursion.

Usage

```
dolpc(x, modelorder = 8)
```

Arguments

x	Matrix of spectral magnitude samples (each sample/time frame in one column).
modelorder	Lag of the AR model.

Value

Returns a matrix of the normalized AR coefficients (depending on the input spectrum: LPC or PLP coefficients). Every column represents one time frame.

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis: http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/

See Also

levinson

Examples

```
testsound <- normalize(sine(400) + sine(1000) + square(250), "16")
pspectrum <- powspec(testsound@left, testsound@samp.rate)
aspectrum <- audspec(pspectrum, testsound@samp.rate)$aspectrum
lpcas <- dolpc(aspectrum, 10)
```

`downsample` *Downsampling a Wave or WaveMC object*

Description

Downsampling an object of class `Wave` or class `WaveMC`.

Usage

```
downsample(object, samp.rate)
```

Arguments

`object`	Object of class `Wave` or class `WaveMC`.
`samp.rate`	Sampling rate the object is to be downsampled to. `samp.rate` must be in `[2000, 192000]`; typical values are 11025, 22050, and 44100 for CD quality. If the `object`'s sampling rate is already equal or smaller than `samp.rate`, the `object` will be returned unchanged.

Value

An object of class `Wave` or class `WaveMC`.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

Wave-class, `Wave`, WaveMC-class, `WaveMC`

equalWave *Checking Wave objects*

Description

Internal S4 generic function that checks for some kind of equality of objects of class Wave or class WaveMC.

Usage

```
equalWave(object1, object2)
```

Arguments

object1, object2
: Object(s) of class Wave or class WaveMC (both of the same class).

Value

Does not return anything. It stops code execution with an error message indicating the problem if the objects are not of the same class (either Wave oder WaveMC) or if the two objects don't have the same properties, i.e. identical sampling rate, resolution (bit), and number of channels (for WaveMC, resp. stereo/mono for Wave).

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg

See Also

Wave-class, Wave, WaveMC-class, WaveMC

extractWave *Extractor for Wave and WaveMC objects*

Description

Extractor function that allows to extract inner parts for Wave or WaveMC objects (interactively).

Usage

```
extractWave(object, from = 1, to = length(object),
    interact = interactive(), xunit = c("samples", "time"), ...)
```

Arguments

object	Object of class Wave or class WaveMC.
from	Sample number or time in seconds (see xunit) at which to *start* extraction.
to	Sample number or time in seconds (see xunit) at which to *stop* extraction. If to < from, object will be returned as is.
interact	Logical indicating whether to choose the range to be extracted interactively (if TRUE). See Section Details.
xunit	Character indicating which units are used to specify the range to be extracted (both in arguments from and to, and in the plot, if interact = TRUE). If xunit = "time", the unit is time in seconds, otherwise the number of samples.
...	Parameters to be passed to the underlying plot function (plot-methods) if interact = TRUE.

Details

This function allows interactive selection of a range to be extracted from an object of class Wave or class WaveMC. The default is to use interactive selection if the current R session is interactive. In case of interactive selection, plot-methods plot the Wave or WaveMC object, and the user may click on the starting and ending points of his selection (given neither from nor to have been specified, see below). The cut-points are drawn and the corresponding selection will be returned in form of a Wave or WaveMC object.

Setting interact = TRUE in a non-interactive session does not work.

Setting arguments from or to explicitly means that the specified one does not need to be selected interactively, hence only the non-specified one will be selected interactively. Moreover, setting both from or to implies interact = FALSE.

Value

An object of class Wave or class WaveMC.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg

See Also

Wave-class, Wave, WaveMC-class, WaveMC, bind, channel, mono

Examples

```
Wobj <- sine(440)
# extracting the middle 0.5 seconds of that 1 sec. sound:
Wobj2 <- extractWave(Wobj, from = 0.25, to = 0.75, xunit = "time")
Wobj2

## Not run:
# or interactively:
Wobj2 <- extractWave(Wobj)
```

```
## End(Not run)
```

FF *Estimation of Fundamental Frequencies from a Wspec object*

Description

Estimation of Fundamental Frequencies from an object of class Wspec. Additionally, some heuristics are used to distinguish silence, noise (and breathing for singers) from real tones.

Usage

```
FF(object, peakheight = 0.01, silence = 0.2, minpeak = 9, diapason = 440,
    notes = NULL, interest.frqs = seq(along = object@freq),
    search.par = c(0.8, 10, 1.3, 1.7))

FFpure(object, peakheight = 0.01, diapason = 440,
    notes = NULL, interest.frqs = seq(along = object@freq),
    search.par = c(0.8, 10, 1.3, 1.7))
```

Arguments

object	An object of class Wspec.
peakheight	The peak's proportion of the maximal peak height to be considered for fundamental frequency detection. The default (0.01) means peaks smaller than 0.02 times the maximal peak height are omitted.
silence	The maximum proportion of periodograms to be considered as silence or noise (such as breathing). The default (0.2) means that less than 20 out of 100 periodograms represent silence or noise.
minpeak	If more than minpeak peaks are considered for detection and passed argument peakheight, such periodograms are detected to be silence or noise (if silence > 0).
diapason	Frequency of diapason a, default is 440 (Hertz).
notes	Optional, a vector of integers indicating the notes (in halftones from diapason a) that are expected. By applying this restriction, the "detection error" might be reduced in some cases.
interest.frqs	Optional, either a vector of integers indicating the indices of (fundamental) frequencies in object that are expected, or one of the character strings "bass", "tenor", "alto" or "soprano". For these voice types, only typical frequency ranges are considered for detection. By applying this restriction, the "detection error" might be reduced in some cases.
search.par	Parameters to look for peaks: 1. The first peak larger than peakheight * 'largest_peak' is taken.

2. Its frequency is multiplied by `1+search.par[1]` Now, any larger peak between the old peak and that value is taken, if (a) it exists and if (b) it is above the `search.par[2]`-th Fourier-Frequency.
3. Within the interval of frequencies `'current peak' * search.par[3:4]`, another high peak is looked for. If any high peak exists in that interval, it can be assumed we got the wrong partial and the 'real' fundamental frequency can be re-estimated from the next two partials.

Details

`FFpure` just estimates the fundamental frequencies for all periodograms contained in the `object` (of class `Wspec`).

`FF` additionally uses some heuristics to distinguish silence, noise (and breathing for singers) from real tones. It is recommended to use the wrapper function `FF` rather than `FFpure`. If silence detecion can be omitted by specifying `silence = 0`.

Value

Vector of estimated fundamental frequencies (in Hertz) for each periodogram conatined in `object`.

Note

These functions are still in development and may be changed in due course.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

`Wspec`, `periodogram` (including an example), `noteFromFF`, and tuneR for a very complete example.

`freqconv` *Frequency scale conversion*

Description

Perform frequency scale conversions between Hertz, Bark- and different variants von the Melscale.

Usage

```
bark2hz(z)
hz2bark(f)
hz2mel(f, htk = FALSE)
mel2hz(z, htk = FALSE)
```

Arguments

f	Frequency in Hertz
z	Frequency in the auditory frequency scale
htk	Use the HTK-Melscale (htk = TRUE) or Slaney's Melscale from the Auditory Toolbox (htk = FALSE)

Value

The value of the input in the target frequency scale.

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis: http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/, Malcolm Slaney: Auditory Toolbox

Examples

```
hz2bark(440)
bark2hz(hz2bark(440))
hz2mel(440, htk = TRUE)
mel2hz(hz2mel(440, htk = TRUE), htk = TRUE)
hz2mel(440, htk = FALSE)
mel2hz(hz2mel(440, htk = FALSE), htk = FALSE)
```

---

getMidiNotes *Extract note events from objects returned by readMidi*

Description

Extract only note events from an object returned by the readMidi function.

Usage

```
getMidiNotes(x, ...)
```

Arguments

x	A data.frame returned by the readMidi function.
...	Further arguments are passed to the notenames function for extracting the human readable note names rather than their integer representations.

Value

A data frame with columns

time	start time
length	length
track	track number
channel	channel number
note	note
notename	notename
velocity	note velocity

Author(s)

Uwe Ligges and Johanna Mielke

See Also

readMidi

Examples

```
content <- readMidi(system.file("example_files", "Bass_sample.mid", package="tuneR"))
getMidiNotes(content)
```

---

length *S4 generic for length*

Description

S4 generic for length.

Methods

x = "Wave" The length of the left channel (in samples) of this object of class Wave will be returned.

x = "WaveMC" The length for each of the time series in the WaveMC will be returned.

object = "ANY" For compatibility.

See Also

For the primitive: length

`lifter` *Liftering of cepstra*

Description

Apply liftering to a matrix of cepstra.

Usage

```
lifter(x, lift = 0.6, inv = FALSE, htk = FALSE)
```

Arguments

`x`	Matrix of cepstra, one sample/time frame per column.
`lift`	Liftering exponent/length.
`inv`	Invert the liftering (undo a previous liftering).
`htk`	Switch liftering type.

Details

If `htk = FALSE`, then perform $xi^l ift$, $i = 1, \ldots,$ `nrow(x)` liftering. If `htk = TRUE`, then perform HTK-style sin-curve liftering with length `lift`.

Value

Matrix of the liftered cepstra.

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis: http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/

Examples

```
testsound <- normalize(sine(400) + sine(1000) + square(250), "16")
m <- melfcc(testsound, frames_in_rows=FALSE)
unlm <- lifter(m, inv=TRUE)
```

`lilyinput` *Providing LilyPond compatible input*

Description

A function *(in development!)* that writes a file to be processed by *LilyPond* by extracting the relevant information (e.g. pitch, length, ...) from columns of a data frame. The music notation software *LilyPond* can "transcribe" such an input file into sheet music.

Usage

```
lilyinput(X, file = "Rsong.ly", Major = TRUE, key = "c",
    clef = c("treble", "bass", "alto", "tenor"), time = "4/4",
    endbar = TRUE, midi = TRUE, tempo = "2 = 60",
    textheight = 220, linewidth = 150, indent = 0, fontsize = 14)
```

Arguments

`X`	A data frame containing 4 named components (columns): • `note`: Integer - the notes' pitch in halftones from diapason (a), i.e. 0 for diapason a, 3 for c', ... • `duration`: Integer - denominator of lengths of the notes, e.g. 8 for a quaver. • `punctate`: Logical - whether to punctate a note. • `slur`: Logical - `TRUE` indicates to start a slur, or to end it. That means that the first, third, ... occurences of `TRUE` start slurps, while the second, fourth, ... occurences end slurps. Note that it is only possible to draw one slur at a time.
`file`	The file to be written for *LilyPond*'s input.
`Major`	Logical indicating major key (if `TRUE`) or minor key.
`key`	Keynote, necessary to set sharps/flats.
`clef`	Integer indicating the kind of clef, supported are `"treble"` (default), `"bass"`, `"alto"`, and `"tenor"`.
`time`	Character indicating which meter to use, examples are: `"3/4"`, `"4/4"`.
`endbar`	Logical indicating whether to set an ending bar at the end of the sheet music.
`midi`	Logical indicating whether Midi output (by *LilyPond*) is desirable.
`tempo`	Character specifying the tempo to be used for the Midi file if `midi = TRUE`. The default, `"2 = 60"` indicates: 60 half notes per minute, whereas `"4 = 90"` indicates 90 quarters per minute.
`textheight`	Textheight of the sheet music to be written by *LilyPond*.
`linewidth`	Linewidth of the sheet music to be written by *LilyPond*.
`indent`	Indentation of the sheet music to be written by *LilyPond*.
`fontsize`	Fontsize of the sheet music to be written by *LilyPond*.

Details

Details will be given when development has reached a stable stage ...!

Value

Nothing is returned, but a `file` is written.

Note

This function is in development!!!
Everything (and in particular its user interface) is subject to change!!!

Author(s)

Andrea Preußer and Uwe Ligges <ligges@statistik.tu-dortmund.de>

References

The LilyPond development team (2005): *LilyPond - The music typesetter*. http://www.lilypond.org/, Version 2.7.20.

Preußer, A., Ligges, U. und Weihs, C. (2002): *Ein R Exportfilter für das Notations- und Midi-Programm LilyPond*. Arbeitsbericht 35. Fachbereich Statistik, Universität Dortmund. (german)

See Also

`quantMerge` prepares the data to be written into the LilyPond format; `quantize` and `quantplot` generate another kind of plot; and exhaustive example is given in tuneR.

`lpc2cep` *LPC to cepstra conversion*

Description

Convert the LPC coefficients in each column of `a` into frames of cepstra.

Usage

```
lpc2cep(a, nout = nrow(a))
```

Arguments

`a`	Matrix of LPC coefficients.
`nout`	Number of cepstra to produce.

Value

Matrix of cepstra (one column per time frame).

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis: http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/

See Also

spec2cep

Examples

```
testsound <- normalize(sine(400) + sine(1000) + square(250), "16")
pspectrum <- powspec(testsound@left, testsound@samp.rate)
aspectrum <- audspec(pspectrum, testsound@samp.rate)
lpcas <- dolpc(aspectrum$aspectrum, 8)
cepstra <- lpc2cep(lpcas)
```

MCnames *Default channel ordering for multi channel wave files*

Description

A data frame representing the default channel ordering with id, descriptive label, and abbreviated name for multi channel wave files.

Format

A data frame with 18 observations on the following 3 variables:

`id` id of the channel

`label` full label for the channel

`name` abbreviated name for the channel

Source

Data derived from the technical documentation given at http://www.microsoft.com/whdc/device/audio/multichaud.mspx.

References

Microsoft Corporation (2007): Multiple Channel Audio Data and WAVE Files, http://www.microsoft.com/whdc/device/audio/multichaud.mspx.

Examples

```
MCnames # the 18 predefined channels in a multi channel Wave file (WaveMC object)
```

melfcc *MFCC Calculation*

Description

Calculate Mel-frequency cepstral coefficients.

Usage

```
melfcc(samples, sr = samples@samp.rate, wintime = 0.025,
    hoptime = 0.01, numcep = 12, lifterexp = 0.6, htklifter = FALSE,
    sumpower = TRUE, preemph = 0.97, dither = FALSE,
    minfreq = 0, maxfreq = sr/2, nbands = 40, bwidth = 1,
    dcttype = c("t2", "t1", "t3", "t4"),
    fbtype = c("mel", "htkmel", "fcmel", "bark"), usecmp = FALSE,
    modelorder = NULL, spec_out = FALSE, frames_in_rows = TRUE)
```

Arguments

samples	Object of Wave-class or WaveMC-class. Only the first channel will be used.
sr	Sampling rate of the signal.
wintime	Window length in sec.
hoptime	Step between successive windows in sec.
numcep	Number of cepstra to return.
lifterexp	Exponent for liftering; 0 = none.
htklifter	Use HTK sin lifter.
sumpower	If `sumpower = TRUE` the frequency scale transformation is based on the power-spectrum, if `sumpower = FALSE` it is based on its squareroot (absolute value of the spectrum) and squared afterwards.
preemph	Apply pre-emphasis filter [1 -preemph] (0 = none).
dither	Add offset to spectrum as if dither noise.
minfreq	Lowest band edge of mel filters (Hz).
maxfreq	Highest band edge of mel filters (Hz).
nbands	Number of warped spectral bands to use.
bwidth	Width of spectral bands in Bark/Mel.
dcttype	Type of DCT used - 1 or 2 (or 3 for HTK or 4 for feacalc).
fbtype	Auditory frequency scale to use: `"mel"`, `"bark"`, `"htkmel"`, `"fcmel"`.
usecmp	Apply equal-loudness weighting and cube-root compression (PLP instead of LPC).
modelorder	If `modelorder > 0`, fit a linear prediction (autoregressive-) model of this order and calculation of cepstra out of `lpcas`.
spec_out	Should matrices of the power- and the auditory-spectrum be returned.
frames_in_rows	Return time frames in rows instead of columns (original Matlab code).

Details

Calculation of the MFCCs imlcudes the following steps:

1. Preemphasis filtering
2. Take the absolute value of the STFT (usage of Hamming window)
3. Warp to auditory frequency scale (Mel/Bark)
4. Take the DCT of the log-auditory-spectrum
5. Return the first 'ncep' components

Value

`cepstra`	Cepstral coefficients of the input signal (one time frame per row/column)
`aspectrum`	Auditory spectrum (spectrum after transformation to Mel/Bark scale) of the signal
`pspectrum`	Power spectrum of the input signal.
`lpcas`	If `modelorder > 0`, the linear prediction coefficients (LPC/PLP).

Note

The following non-default values nearly duplicate Malcolm Slaney's mfcc (i.e.

```
melfcc(d, 16000, wintime=0.016, lifterexp=0, minfreq=133.33,
       maxfreq=6855.6, sumpower=FALSE)
```

=~= `log(10) * 2 * mfcc(d, 16000)` in the Auditory toolbox for Matlab).

The following non-default values nearly duplicate HTK's MFCC (i.e.

```
melfcc(d, 16000, lifterexp=22, htklifter=TRUE, nbands=20, maxfreq=8000,
    sumpower=FALSE, fbtype="htkmel", dcttype="t3")
```

=~= `2 * htkmelfcc(:,[13,[1:12]])` where HTK config has 'PREEMCOEF = 0.97', 'NUMCHANS = 20', 'CEPLIFTER = 22', 'NUMCEPS = 12', 'WINDOWSIZE = 250000.0', 'USEHAMMING = T', 'TARGETKIND = MFCC_0').

For more detail on reproducing other programs' outputs, see http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/mfccs.html

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis: http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/

Examples

```
testsound <- normalize(sine(400) + sine(1000) + square(250), "16")
m1 <- melfcc(testsound)

#Use PLP features to calculate cepstra and output the matrices like the
#original Matlab code (note: modelorder limits the number of cepstra)
m2 <- melfcc(testsound, numcep=9, usecmp=TRUE, modelorder=8,
  spec_out=TRUE, frames_in_rows=FALSE)
```

`melodyplot` *Plotting a melody*

Description

Plot a observed melody and (optional) an expected melody, as well as corresponding energy values (corresponding to the loudness of the sound).

Usage

```
melodyplot(object, observed, expected = NULL, bars = NULL,
    main = NULL, xlab = NULL, ylab = "note", xlim = NULL, ylim = NULL,
    observedtype = "l", observedcol = "red", expectedcol = "grey",
    gridcol = "grey", lwd = 2, las = 1, cex.axis = 0.9,
    mar = c(5, 4, 4, 4) + 0.1, notenames = NULL, thin = 1,
    silence = "silence", plotenergy = TRUE, ...,
    axispar = list(ax1 = list(side=1),
                   ax2 = list(side=2),
                   ax4 = list(side=4)),
    boxpar = list(),
    energylabel = list(text="energy", side=4, line=2.5, at=rg.s-0.25, las=3),
    energypar = list(),
    expectedpar = list(),
    gridpar = list(col=gridcol),
    observedpar = list(col=observedcol, type=observedtype, lwd=2, pch=15))
```

Arguments

`object`	An object of class `Wspec`.
`observed`	Observed notes, probably as a result from `noteFromFF` (or a smoothed version). This should correspond to the `Wspec` `object`. It can also be a matrix of `k` columns where those `k` notes in the same row are displayed at the same timepoint.
`expected`	Expected notes (optional; in order to compare results), same format as `observed`.
`bars`	Number of bars to be plotted (a virtual static segmentation takes place). If `NULL` (default), time rather than bars are used.
`main`	Main title of the plot.

xlab, ylab	Annotation of -/y-axes.
xlim, ylim	Range of x-/y-axis, where ylim must be an integer that represents the range of note heights that should be displayed.
observedtype	Type (either "p" for points or "l" for lines) used for representing observed notes. "l" (the default) is not sensible for polyphonic representations.
observedcol	Colour for the observed melody.
expectedcol	Colour for the expected melody.
gridcol	Colour of the grid.
lwd	Line width, see par for details.
las	Orientation of axis labels, see par for details.
cex.axis	Size of tick mark labels, see par for details.
mar	Margins of the plot, see par for details.
notenames	Optionally specify other notenames (character) for the y axis.
thin	Amount of thinning of notenames, i.e. only each thinth notename is displayed on the y-axis.
silence	Character string for label of the 'silence' (default) axis.
plotenergy	Logical (default: TRUE), whether to plot energy values in the bottom part of the plot.
...	Additional graphical parameters to be passed to underlying plot function.
axispar	A named list of three other lists (ax1, ax2, and ax4) containing parameters passed to the corresponding axis calls for the three axis time (ax1), notes (ax2), and energy (ax4).
boxpar	A list of parameters to be passed to the box generating functions.
energylabel	A list of parameters to be passed to the energy-label generating mtext call.
energypar	A list of parameters to be passed to the lines function that draws the energy curve.
expectedpar	A list of parameters to be passed to the rect function that draws the rectangles for expected values.
gridpar	A list of parameters to be passed to the abline function that draws the grid lines.
observedpar	A list of parameters to be passed to the lines function that draws the observed values.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

noteFromFF, FF, quantplot; for an example, see the help in tuneR.

MFCC *DEFUNCT: Mel Frequency Cepstral Coefficients*

Description

DEFUNCT: Computation of MFCCs — this has been replaced by melfcc already and is just a wrapper! Will be removed shortly.

Note

This function was always documented to be in development and highly EXPERIMENTAL!!!

See Also

melfcc

Mono-Stereo *Converting (extracting, joining) stereo to mono and vice versa*

Description

Functions to extract a channel from a stereo Wave object, and to join channels of two monophonic Wave objects to a stereophonic one.

Usage

```
mono(object, which = c("left", "right", "both"))
stereo(left, right)
```

Arguments

object	Object of class Wave.
which	Character, indicating whether the "left" or "right" channel should be extracted, or whether "both" channels should be averaged.
left	Object of class Wave containing monophonic sound, to be used for the left channel.
right	Object of class Wave containing monophonic sound, to be used for the right channel (if missing, the left channel is duplicated). If right is missing, stereo returns whether left is stereo (TRUE) or mono (FALSE).

Details

For objects of WaveMC-class, a mono channel can be created by simple matrix indexing, e.g. WaveMCobject[,2] selects the second channel.

Value

An object of class Wave.

If argument right is missing in stereo, a logical values is returned that indicates whether left is stereo (TRUE) or mono (FALSE).

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

Wave-class, Wave

Examples

```
Wobj <- sine(440)
Wobj
Wobj2 <- stereo(Wobj, Wobj)
Wobj2
mono(Wobj2, "right")
```

---

nchannel *Number of channels*

Description

Get the number of channels from a Wave or WaveMC object

Usage

```
nchannel(object)
## S4 method for signature 'Wave'
nchannel(object)
## S4 method for signature 'WaveMC'
nchannel(object)
```

Arguments

object	Object of class Wave or class WaveMC.

Value

An integer, the number of channels given in the object.

See Also

Wave-class, WaveMC-class

normalize-methods *Rescale the range of values*

Description

Centering and rescaling the waveform of a Wave or WaveMC object to a canonical interval corresponding to the Wave format (e.g. [-1, 1], [0, 254], [-32767, 32767], [-8388607, 8388607], or [-2147483647, 2147483647]).

Usage

```
normalize(object, unit = c("1", "8", "16", "24", "32", "64", "0"),
    center = TRUE, level = 1, rescale = TRUE, pcm = object@pcm)
```

Arguments

object	Object of class Wave or WaveMC.
unit	Unit to rescale to. "1" (default) for rescaling to numeric values in [-1, 1], "8" (i.e. 8-bit) for rescaling to integers in [0, 254], "16" (i.e. 16-bit) for rescaling to integers in [-32767, 32767], "24" (i.e. 24-bit) for rescaling to integers in [-8388607, 8388607], "32" (i.e. 32-bit) for rescaling either to integers in [-2147483647, 2147483647] (PCM Wave format if pcm=TRUE) or to numeric values in [-1, 1] (FLOAT_IEEE Wave format if pcm = FALSE), "64" (i.e. 64-bit) for rescaling to real values in [-1, 1] (FLOAT_IEEE Wave format), and "0" for not rescaling (hence only centering if center = TRUE).
center	If TRUE (default), values are centered around 0 (or 127 if unit = "8").
level	Maximal percentage of the amplitude used for normalizing (default is 1).
rescale	Logical, whether to rescale to the maximal possible dynamic range.
pcm	Logical. By default, the pcm information from the object is kept. Otherwise, if TRUE, the object is coerced to the PCM Wave format. If FALSE, the object is coerced to the FLOAT_IEEE format, i.e. numeric values in [-1, 1].

Value

An object containing the normalized data of the same class as the input object, i.e. either Wave or WaveMC.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg, based on code from Matthias Heymann's former package 'sound'.

See Also

writeWave, Wave-class, Wave, WaveMC-class, WaveMC

---

noSilence *Cut off silence from a Wave or WaveMC object*

Description

Generic function to cut off silence or low noise at the beginning and/or at the end of an object of class Wave or class WaveMC.

Usage

```
noSilence(object, zero = 0, level = 0, where = c("both", "start", "end"))
```

Arguments

object	Object of class Wave or class WaveMC.
zero	The zero level (default: 0) at which ideal cut points are determined (see Details). A typical alternative would be 127 for 8 bit Wave or WaveMC objects. If zero = NA, the mean of the left Wave channel (for Wave, resp. the mean of the first channel for WaveMC) is taken as zero level.
level	Values in the interval between zero and zero - level/zero + level are considered as silence.
where	One of "both" (default), "start", or "end" indicating at where to prepare the Wave or WaveMC object for concatenation.

Details

Silcence is removed at the locations given by where of the Wave or WaveMC object, where silence is defined such that (in both channels if stereo, in all channels if multichannel for WaveMC) all values are in the interval between zero - level and zero + level. All values before (or after, respectively) the first non-silent value are removed from the object.

Value

An object of class Wave or WaveMC.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg, based on code from Matthias Heymann's former package 'sound'.

See Also

silence, Wave-class, Wave, WaveMC-class, WaveMC, extractWave

noteFromFF *Deriving notes from frequencies*

Description

Deriving notes from given (fundamental) frequencies.

Usage

```
noteFromFF(x, diapason = 440, roundshift = 0)
```

Arguments

x	Fundamental frequency.
diapason	Frequency of diapason a, default is 440 (Hertz).
roundshift	Shift that indicates from here to round to the next integer (note). The default (0) is "classical" rounding as described in round. A higher value means that roundshift is added to the calculated real note value before rounding to an integer. This is useful if it is unclear that some instruments really shift the note in the center between two theoretical frequencies. Example: if x = 452 and diapason = 440, the internally calculated real value of 0.46583 is rounded to 0, but for roundshift = 0.1 we get 0.56583 and it is rounded to note 1.

Details

The formula used is simply round(12 * log(x / diapason, 2) + roundshift).

Value

An integer representing the (rounded) difference in halftones from diapason a, i.e. indicating the note that corresponds to fundamental frequency x given the value of diapason. For example: 0 indicates diapason a, 3: c', 12: a', ...

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

FF, periodogram, and tuneR for a very complete example.

notenames *Generating note names from numbers*

Description

A function that generates note names from numbers

Usage

```
notenames(notes, language = c("english", "german"))
```

Arguments

notes	An interger values vector, where 0 corresponds to a', notes below and above have to be specified in the corresponding halftone distance.
language	Language of the note names. Currently only english and german are supported.

Value

A character vector of note names.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

Examples

```
notenames(c(-24, -12, 0, 12)) # octaves of a
notenames(3:15)               # chromaticism

## same in german:
notenames(3:15, language = "german")
```

panorama *Narrow the Panorama of a Stereo Sample*

Description

Generic function to narrow the panorama of a stereo Wave or WaveMC object.

Usage

```
panorama(object, pan = 1)
```

Arguments

object	Object of class Wave or class WaveMC.
pan	Value in [-1,1] to narrow the panorama, see the Details below. The default (1) does not change anything.

Details

If abs(pan) < 1, mixtures of the two channels of the Wave or WaveMC objects are used for the left and the right channel of the returned Sample object if the object is of class Wave, resp. for the first and second channel of the returned Sample object if the object is of class WaveMC, so that they appear closer to the center.

For pan = 0, both sounds are completely in the center (i.e. averaged).

If pan < 0, the left and the right channel (for Wave objects, the first and the second channel for WaveMC objects) are interchanged.

Value

An object of class Wave or class WaveMC with the transformed panorama.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg, based on code by Matthias Heymann

See Also

Wave-class, Wave, WaveMC-class, WaveMC

---

periodogram-methods *Periodogram (Spectral Density) Estimation on Wave objects*

Description

This function estimates one or more periodograms (spectral densities) of the time series contained in an object of class Wave or WaveMC (or directly in a Wave file) using a window running through the time series (possibly with overlapping). It returns an object of class Wspec.

Usage

```
periodogram(object, ...)
## S4 method for signature 'WaveGeneral'
periodogram(object, width = length(object), overlap = 0,
    starts = NULL, ends = NULL, taper = 0, normalize = TRUE,
    frqRange = c(-Inf, Inf), ...)
## S4 method for signature 'character'
periodogram(object, width, overlap = 0, from = 1, to = Inf,
    units = c("samples", "seconds", "minutes", "hours"),
    downsample = NA, channel = c("left", "right"), pieces = 1, ...)
```

Arguments

object	An object of class Wave, WaveMC, or a character string pointing to a Wave file.
width	A window of width 'width' running through the time series selects the samples from which the periodograms are to be calculated.
overlap	The window can be applied by each overlapping overlap samples.
starts	Start number (in samples) for a window. If not given, this value is derived from argument ends, or will be derived width and overlap.
ends	End number (in samples) for a window. If not given, this value is derived from argument starts, or will be derived from width and overlap.
taper	proportion of data to taper. See spec.pgram for details.
normalize	Logical; if TRUE (default), two steps will be applied: (i) the input signal will be normalized to amplitude max(abs(amplitude)) == 1, (ii) the resulting spec values will be normalized to sum up to one for each periodogram.
frqRange	Numeric vector of two elements indicating minimum and maximum of the frequency range that is to be stored in the resulting object. This is useful to reduce memory consumption.
from	Where to start reading in the Wave file, in units.
to	Where to stop reading in the Wave file, in units.
units	Units in which from and to is given, the default is "samples", but can be set to time intervals such as "seconds", see the Usage Section above.
downsample	Sampling rate the object is to be downsampled to. If NA, the default, no changes are applied. Otherwise downsample must be in [2000, 192000]; typical values are 11025, 22050, and 44100 for CD quality. See also downsample.
channel	Character, indicating whether the "left" or "right" channel should be extracted (see mono for details) - stereo processing is not yet implemented.
pieces	The Wave file will be read in in pieces steps in order to reduce the amount of required memory.
...	Further arguments to be passed to the underlying function spec.pgram.

Value

An object of class Wspec is returned containing the following slots.

freq	Vector of frequencies at which the spectral density is estimated. See spectrum for details. (1)
spec	List of vectors or matrices of the spec values returned by spec.pgram at frequencies corresponding to freq. Each element of the list corresponds to one periodogram estimated from samples of the window beginning at start of the Wave or WaveMC object.
kernel	The kernel argument, or the kernel constructed from spans returned by spec.pgram. (1)
df	The distribution of the spectral density estimate can be approximated by a chi square distribution with df degrees of freedom. (1)

taper	The value of the taper argument. (1)
width	The value of the width argument. (1)
overlap	The value of the overlap argument. (1)
normalize	The value of the normalize argument. (1)
starts	If the argument starts was given in the call, its value. If the argument ends was given in the call, 'ends - width'. If neither starts nor ends was given, the start points of all periodograms. In the latter case the start points are calculated from the arguments width and overlap.
stereo	Always FALSE (for back compatibility). (1)
samp.rate	Sampling rate of the underlying Wave or WaveMC object. (1)
variance	The variance of samples in each window, corresponding to amplitude / loudness of sound.
energy	The "energy" E, also an indicator for the amplitude / loudness of sound: $$E(x_I) := 20 * log_{10} \sum_{j \in I} \lvert x_j \rvert,$$ where I indicates the interval $I :=$ start[i]:end[i] for all $i := 1, \ldots,$ length(starts).

Those slots marked with "(1)" contain the information once, because it is unique for all periodograms of estimated by the function call.

Note

Support for processing more than one channel of Wave or WaveMC objects has not yet been implemented.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

- for the resulting objects' class: Wspec,
- for plotting: plot-Wspec,
- for the underlying periodogram calculations: spec.pgram,
- for the input data class: Wave-class, Wave, WaveMC-class, WaveMC.

Examples

```
# constructing a Wave object (1 sec.) containing sinus sound with 440Hz:
Wobj <- sine(440)
Wobj

# Calculate periodograms in windows of 4096 samples each - without
#   any overlap - resulting in an Wspec object that is printed:
```

```
Wspecobj <- periodogram(Wobj, width = 4096)
Wspecobj

# Plot the first periodogram from Wspecobj:
plot(Wspecobj)
# Plot the third one and choose a reasonable xlim:
plot(Wspecobj, which = 3, xlim = c(0, 1000))
# Mark frequency that has been generated before:
abline(v = 440, col="red")

FF(Wspecobj)              # all ~ 440 Hertz
noteFromFF(FF(Wspecobj))  # all diapason a
```

`play-methods` *Playing Waves*

Description

Plays wave files and objects of class `Wave`.

Usage

```
play(object, player, ...)
```

Arguments

`object`	Either a filename pointing to a Wave file, or an object of class `Wave` or `WaveMC`. If the latter, it is written to a temporary file by `writeWave`, played by the chosen player, and deleted afterwards.
`player`	(Path to) a program capable of playing a wave file by invocation from the command line. If under Windows and no player is given, "mplay32.exe" or "wmplayer.exe" (if the former does not exists as under Windows 7) will be chosen as the default.
`...`	Further arguments passed to the Wave file `player`. If no `player` and no further arguments are given under Windows, the default is: `"/play /close"`.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

Wave-class, WaveMC-class, `Wave`, `WaveMC`, `writeWave`, `setWavPlayer`

plot-Wave *Plotting Wave objects*

Description

Plotting objects of class Wave.

Usage

```
## S4 method for signature 'Wave,missing'
plot(x, info = FALSE, xunit = c("time", "samples"),
    ylim = NULL, main = NULL, sub = NULL, xlab = NULL, ylab = NULL,
    simplify = TRUE, nr = 2500, axes = TRUE, yaxt = par("yaxt"), las = 1,
    center = TRUE, ...)

## S4 method for signature 'WaveMC,missing'
plot(x, info = FALSE, xunit = c("time", "samples"),
    ylim = NULL, main = NULL, sub = NULL, xlab = NULL, ylab = colnames(x),
    simplify = TRUE, nr = 2500, axes = TRUE, yaxt = par("yaxt"), las = 1,
    center = TRUE, mfrow = NULL, ...)

plot.Wave.channel(x, xunit, ylim, xlab, ylab, main, nr, simplify, axes = TRUE,
    yaxt = par("yaxt"), las = 1, center = TRUE, ...)
```

Arguments

x	Object of class Wave or WaveMC, respectively.
info	Logical, whether to include (written) information on the Wave or WaveMC object within the plot.
xunit	Character indicating which units are used for setting up user coordinates (see par) and x-axis labeling. If xunit = "time", the unit is time in seconds, otherwise the number of samples.
ylim	The y (amplitude) limits of the plot.
main, sub	A title / subtitle for the plot.
xlab	Label for x-axis.
ylab	Label for y-axis (on the right side of the plot). For WaveMC objects, this can be the default colnames(x) (i.e. channel names of the WaveMC object), NULL for "channel 1", ..., "channel nc" where nc is ncol(x), NA for no labels, or a character vector of labels (one element for each channel). For Wave objects, this can be de default "left channel" (for mono) or "left channel" and "right channel" (for stereo), NA for no labels, or a character vector of labels (one element for each channel).
simplify	Logical, whether the plot should be "simplified". If TRUE (default), not all (thousand/millions/billions) of points (samples) of the Wave or WaveMC object are

	drawn, but the nr (see below) ranges (in form of segments) within nr windows of the time series. Plotting with simplify = FALSE may take several minutes (depending on the number of samples in the Wave or WaveMC) and output in any vector format may be really huge.
nr	Number of windows (segments) to be used *approximately* (an appropriate number close to nr is selected) to simplify (see above) the plot. Only used if simplify = TRUE and the number of samples of the Wave or WaveMC object x is larger.
axes	Whether to plot axes, default is TRUE.
yaxt	How to plot the y-axis ("n" for no y-axis).
las	The style of the axis labels, default is las = 1 (always horizontal), see par for details.
center	Whether to plot with y-axes centered around 0 (or 127 if 8-bit), default is TRUE.
mfrow	A vector indicating the arrangement of the figures, see par for details.
...	Further arguments to be passed to the underlying plot functions.

Details

Function plot.Wave.channel is a helper function to plot a single channel (left for a Wave object, first channel / first column of data slot of a WaveMC object); in particular it is *not* intended to be called by the user directly.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg

See Also

Wave-class, Wave, WaveMC-class, WaveMC and tuneR

---

plot-Wspec *Plotting Wspec objects*

Description

Plotting a periodogram contained in an object of class Wspec.

Usage

```
## S4 method for signature 'Wspec,missing'
plot(x, which = 1, type = "h", xlab = "Frequency",
    ylab = NULL, log = "", ...)
```

Arguments

x	Object of class Wspec.
which	Integer indicating which of the periodograms contained in object x to plot. Default is to plot the first one.
type	The default is to plot horizontal lines, rather than points. See plot.default for details.
xlab, ylab	Label for x-/y-axis.
log	Character - "x" if the x-axis is to be logarithmic, "y" if the y-axis is to be logarithmic (quite typical for some visualizations of periodograms), and "xy" or "yx" if both axes are to be logarithmic.
...	Further arguments to be passed to the underlying plot functions. See plot.default for details.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

see Wspec, periodogram and tuneR for the constructor function and some examples.

---

plot-WspecMat *Plotting WspecMat objects*

Description

Plotting a spectogram (image) of an object of class Wspec or WspecMat.

Usage

```
## S4 method for signature 'WspecMat,missing'
plot(x, xlab = "time", ylab = "Frequency",
    xunit = c("samples", "time"), log = "", ...)
## S4 method for signature 'Wspec'
image(x, xlab = "time", ylab = "Frequency",
    xunit = c("samples", "time"), log = "", ...)
```

Arguments

x	Object of class WspecMat (for plot) or Wspec (for image).
xlab, ylab	Label for x-/y-axis.
xunit	Character indicating which units are used to annotate the x-axis. If xunit = "time", the unit is time in seconds, otherwise the number of samples.
log	Character - "z" if the z values are to be logarithmic.
...	Further arguments to be passed to the underlying image function. See image for details.

Details

Calling `image` on a `Wspec` object converts it to class `WspecMat` and calls the corresponding `plot` function.
Calling `plot` on a `WspecMat` object generates an `image` with correct annotated axes.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

see `image`, `Wspec`, `WspecMat`, `periodogram` and tuneR for the constructor function and some examples.

`postaud` *Equal loudness compression*

Description

Do loudness equalization and cube root compression

Usage

```
postaud(x, fmax, fbtype = c("bark", "mel", "htkmel", "fcmel"),
    broaden = FALSE)
```

Arguments

`x`	Matrix of spectra (output of `audspec`).
`fmax`	Maximum frequency im Hertz.
`fbtype`	Auditory frequency scale.
`broaden`	Use two additional frequency bands for calculation.

Value

`x`	Matrix of the per sample/frame (columns) spectra after applying the frequency dependant loudness equalization and compression.
`eql`	Vector of the equal loudness curve.

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/, Hynek Hermansky

See Also

audspec, dolpc

Examples

```
testsound <- normalize(sine(400) + sine(1000) + square(250), "16")
pspectrum <- powspec(testsound@left, testsound@samp.rate)
aspectrum <- audspec(pspectrum, testsound@samp.rate)
paspectrum <- postaud(x = aspectrum$aspectrum, fmax = 5000,
  fbtype = "mel")
```

---

powspec *Powerspectrum*

Description

Compute the powerspectrum of the input signal. Basically output a power spectrogram using a Hamming window.

Usage

```
powspec(x, sr = 8000, wintime = 0.025, steptime = 0.01, dither = FALSE)
```

Arguments

x	Vector of samples.
sr	Sampling rate of the signal.
wintime	Window length in sec.
steptime	Step between successive windows in sec.
dither	Add offset to spectrum as if dither noise.

Value

Matrix, where each column represents a power spectrum for a given frame and each row represents a frequency.

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis: http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/

See Also

specgram

Examples

```
testsound <- normalize(sine(400) + sine(1000) + square(250), "16")
pspectrum <- powspec(testsound@left, testsound@samp.rate)
```

---

prepComb *Preparing the combination/concatenation of Wave or WaveMC objects*

Description

Preparing objects of class Wave or class WaveMC for binding/combination/concatenation by removing small amounts at the beginning/end of the Wave or WaveMC in order to make the transition smooth by avoiding clicks.

Usage

```
prepComb(object, zero = 0, where = c("both", "start", "end"))
```

Arguments

object	Object of class Wave or class WaveMC.
zero	The zero level (default: 0) at which ideal cut points are determined (see Details). A typical alternative would be 127 for 8 bit Wave or WaveMC objects. If zero = NA, the mean of the left Wave channel (for a Wave object) or the mean of the first channel (for a WaveMC object) is taken as zero level.
where	One of "both" (default), "start", or "end" indicating at where to prepare the Wave or WaveMC object for concatenation.

Details

This function is useful to prepare objects of class Wave or class WaveMC for binding/combination/concatenation. At the side(s) indicated by where small amounts of the Wave or WaveMC are removed in order to make the transition between two Waves or WaveMCs smooth (avoiding clicks).

This is done by dropping all values at the *beginning* of a Wave or WaveMC before the first positive point after the zero level is crossed from negative to positive. Analogously, at the *end* of a Wave or WaveMC all points are cut after the last negative value before the last zero level crossing from negative to positive.

Value

An object of class Wave or class WaveMC.

Note

If stereo (for Wave), only the left channel is analyzed while the right channel will simply be cut at the same locations. If multi channel (for WaveMC), only the first channel is analyzed while all other channels will simply be cut at the same locations.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg, based on code from Matthias Heymann's former package 'sound'.

See Also

bind, Wave-class, Wave, WaveMC-class, WaveMC, extractWave, and noSilence to cut off silence

Examples

```
Wobj1 <- sine(440, duration = 520)
Wobj2 <- extractWave(sine(330, duration = 500), from = 110, to = 500)
par(mfrow = c(2,1))
plot(bind(Wobj1, Wobj2), xunit = "samples")
abline(v = 520, col = "red")  # here is a "click"!

# now remove the "click" by deleting a minimal amount of information:
Wobj1 <- prepComb(Wobj1, where = "end")
Wobj2 <- prepComb(Wobj2, where = "start")
plot(bind(Wobj1, Wobj2), xunit = "samples")
```

---

quantize *Functions for the quantization of notes*

Description

These functions apply (static) quantization of notes in order to produce sheet music by pressing the notes into bars.

Usage

```
quantize(notes, energy, parts)
quantMerge(notes, minlength, barsize, bars)
```

Arguments

notes	Series of notes, a vector of integers such as returned by noteFromFF. At least one argument (notes and/or energy) must be specified.
energy	Series of energy values, a vector of numerics such as corresponding components of a Wspec object.
parts	Number of outcoming parts. The notes vector is divided into parts bins, the outcome is a vector of the modes of all bins.
minlength	1/(length of the shortest note). Example: if the shortest note is a quaver (1/8), set minlength = 8.
barsize	One bar contains barsize number of notes of length minlength.
bars	We expect bars number of bars.

Value

`quantize` returns a list with components:

`notes`	Vector of length `parts` corresponding to the input data The data is binned and modes corresponding to the data in those bins are returned.
`energy`	Same as `notes`, but for the `energy` argument.

`quantMerge` returns a data.frame with components:

`note`	integer representation of a note (see Arguments).
`duration`	1/duration of a note (see `minlength` in Section Arguments), if `punctuation = FALSE`.
`punctuation`	Whether the note should be punctuated. If `TRUE`, the real duration is 1.5 times the duration given in `duration`.
`slur`	currently always `FALSE`, sensible processing is not yet implemented. It is supposed to indicate the beginning and ending positions of slurs.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

to get the input: `noteFromFF`, for plotting: `quantplot`, for further processing: `lilyinput`, to get notenames: `notenames`; for an example, see the help in tuneR.

`quantplot` *Plotting the quantization of a melody*

Description

Plot an observed melody and (optional) an expected melody, as well as corresponding energy values (corresponding to the loudness of the sound) within a quantization grid.

Usage

```
quantplot(observed, energy = NULL, expected = NULL, bars,
    barseg = round(length(observed) / bars),
    main = NULL, xlab = NULL, ylab = "note", xlim = NULL, ylim = NULL,
    observedcol = "red", expectedcol = "grey", gridcol = "grey",
    lwd = 2, las = 1, cex.axis = 0.9, mar = c(5, 4, 4, 4) + 0.1,
    notenames = NULL, silence = "silence", plotenergy = TRUE, ...,
    axispar = list(ax1 = list(side=1), ax2 = list(side=2), ax4 = list(side=4)),
    boxpar = list(),
    energylabel = list(text="energy", side=4, line=2.5, at=rg.s-0.25, las=3),
    energypar = list(pch=20),
    expectedpar = list(),
    gridpar = list(gridbar = list(col = 1), gridinner = list(col=gridcol)),
    observedpar = list(col=observedcol, pch=15))
```

Arguments

observed	Either a vector of observed notes resulting from some quantization, or a list with components notes (observed notes) and energy (corresponding energy values), e.g. the result from a call to quantize.
energy	A vector of energy values with same quantization as observed (overwrites any given energy values if observed is a list).
expected	Expected notes (optional; in order to compare results).
bars	Number of bars to be plotted (e.g. corresponding to quantize arguments).
barseg	Number of segments (minimal length notes) in each bar.
main	Main title of the plot.
xlab, ylab	Annotation of x-/y-axes.
xlim, ylim	Range of x-/y-axis.
observedcol	Colour for the observed notes.
expectedcol	Colour for the expected notes.
gridcol	Colour of the inner-bar grid.
lwd	Line width, see par for details.
las	Orientation of axis labels, see par for details.
cex.axis	Size of tick mark labels, see par for details.
mar	Margins of the plot, see par for details.
notenames	Optionally specify other notenames (character) for the y-axis.
silence	Character string for label of the 'silence' (default) axis.
plotenergy	Logical indicating whether to plot energy values in the bottom part of the plot (default is TRUE) if energy values are specified, and FALSE otherwise.
...	Additional graphical parameters to be passed to underlying plot function.
axispar	A named list of three other lists (ax1, ax2, and ax4) containing parameters passed to the corresponding axis calls for the three axis time (ax1), notes (ax2), and energy (ax4).
boxpar	A list of parameters to be passed to the box generating functions.
energylabel	A list of parameters to be passed to the energy-label generating mtext call.
energypar	A list of parameters to be passed to the points function that draws the energy values.
expectedpar	A list of parameters to be passed to the rect function that draws the rectangles for expected values.
gridpar	A named list of two other lists (gridbar and gridinner) containing parameters passed to the abline functions that draw the grid lines (for bar separators and inner bar (note) separators).
observedpar	A list of parameters to be passed to the lines function that draws the observed values.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

noteFromFF, FF, melodyplot, quantize; for an example, see the help in tuneR.

---

readMidi *Read a MIDI file*

Description

A MIDI file is read and returned in form of a structured data frame containing most event information (minus some meta events and minus all system events). For details about the represented information see the reference given below.

Usage

```
readMidi(file)
```

Arguments

file	Filename of MIDI file.

Value

A data frame consisting of columns

time	Time or delta-time of the events, depending on the MIDI format.
event	A factor indicating the event.
type	An integer indicating the type of a "meta event", otherwise NA.
channel	The channel number or NA if not applicable.
parameter1	First parameter of an event, e.g. a representation for a note in a "note event".
parameter2	Second parameter of an event.
parameterMetaSystem	Information in a "meta event", currently all meta events are converted to a character representation (of hex, if all fails), but future versions may have more appropriate representations.
track	The track number.

Please see the given reference about the MIDI file format about details.

Note

The data structure may be changed or extended in future versions.

Author(s)

Uwe Ligges and Johanna Mielke

References

A good reference about the Midi file format can be found at http://www.music.mcgill.ca/~ich/classes/mumt306/StandardMIDIfileformat.html.

See Also

The function getMidiNotes extracts a more readable representation of note events only.

You may also want to read Wave (readWave) or MP3 (readMP3).

Examples

```
content <- readMidi(system.file("example_files", "Bass_sample.mid", package="tuneR"))
str(content)
content
```

---

readMP3 *Read an MPEG-2 layer 3 file into a Wave object*

Description

A bare bones MPEG-2 layer 3 (MP3) file reader that returns the results as 16bit PCM data stored in a Wave object.

Usage

```
readMP3(filename)
```

Arguments

filename	Filename of MP3 file.

Value

A Wave object.

Note

The decoder can currently only handle files which are either mono or stereo. This is a limitation of the Wave object and the underlying MAD decoder.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

References

The decoder source code is taken from the MAD library, see http://www.underbit.com/products/mad/.

See Also

Wave

Examples

```
## Not run:
## Requires an mp3 file named sample.mp3 in the current directory.
mpt <- readMP3("sample.mp3")
summary(mpt)

## End(Not run)
```

---

readWave *Reading Wave files*

Description

Reading Wave files.

Usage

```
readWave(filename, from = 1, to = Inf,
   units = c("samples", "seconds", "minutes", "hours"), header = FALSE, toWaveMC = NULL)
```

Arguments

filename	Filename of the file to be read.
from	Where to start reading (in order to save memory by reading wave file piecewise), in units.
to	Where to stop reading (in order to save memory by reading wave file piecewise), in units.
units	Units in which from and to is given, the default is "samples", but can be set to time intervals such as "seconds", see the Usage Section above.
header	If TRUE, just header information of the Wave file are returned, otherwise (the default) the whole Wave object.
toWaveMC	If TRUE, a WaveMC-class object is returned. If NULL (default) or FALSE and a non-extensible Wave file or an extensible Wave file with no other than the "FL" and "FR" channels is found, a Wave-class object is returned, otherwise a WaveMC-class object.

Value

An object of class Wave or WaveMC or a list containing just the header information if header = TRUE. If the latter, some experimental support for reading bext chunks in Broadcast Wave Format files is implemented, and the content is returned as an unprocessed string (character).

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg

See Also

Wave-class, Wave, WaveMC-class, WaveMC, writeWave

Examples

```
Wobj <- sine(440)

tdir <- tempdir()
tfile <- file.path(tdir, "myWave.wav")
writeWave(Wobj, filename = tfile)
list.files(tdir, pattern = "\\.wav$")
newWobj <- readWave(tfile)
newWobj
file.remove(tfile)
```

---

show-WaveWspec-methods

Showing objects

Description

Showing Wave, Wspec, and WspecMat objects.

Methods

object = "Wave" The Wave object is being shown. The number of samples, duration in seconds, Samplingrate (Hertz), Stereo / Mono, PCM / IEEE, and the resolution in bits are printed. Note that it does not make sense to print the whole channels containing several thousands or millions of samples.

object = "WaveMC" The WaveMC object is being shown. The number of samples, duration in seconds, Samplingrate (Hertz), number of channels, PCM / IEEE, and the resolution in bits are printed. Note that it does not make sense to print the whole channels containing several thousands or millions of samples.

object = "Wspec" The number of periodograms, Fourier frequencies, window width (used amount of data), amount of overlap of neighboring windows, and whether the periodogram(s) has/have been normalized will be printed.

object = "WspecMat" The number of periodograms, Fourier frequencies, window width (used amount of data), amount of overlap of neighboring windows, and whether the periodogram(s) has/have been normalized will be printed.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

Wave-class, Wave, WaveMC-class, WaveMC, Wspec, WspecMat, plot-methods, summary-methods, and periodogram for the constructor function and some examples

---

smoother *Meta Function for Smoothers*

Description

Apply a smoother to estimated notes. Currently, only a running median (using decmedian in package **pastecs**) is available.

Usage

```
smoother(notes, method = "median", order = 4, times = 2)
```

Arguments

notes	Series of notes, a vector of integers such as returned by noteFromFF.
method	Currently, only a running 'median' (using decmedian in package **pastecs**) is available.
order	The window used for the running median corresponds to 2*order + 1.
times	The number of times the running median is applied (default: 2).

Value

The smoothed series of notes.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

spec2cep *Spectra to Cepstra Conversion*

Description

Calculate cepstra from spectral samples (in columns of spec) through Discrete Cosine Transformation.

Usage

```
spec2cep(spec, ncep = 12, type = c("t2", "t1", "t3", "t4"))
```

Arguments

spec	Input spectra (samples/time frames in columns).
ncep	Number of cepstra to return.
type	DCT Type.

Value

cep	Matrix of resulting cepstra.
dctm	Returns the DCT matrix that spec was multiplied by to give cep.

Author(s)

Sebastian Krey <krey@statistik.tu-dortmund.de>

References

Daniel P. W. Ellis: http://www.ee.columbia.edu/~dpwe/resources/matlab/rastamat/

See Also

lpc2cep

Examples

```
testsound <- normalize(sine(400) + sine(1000) + square(250), "16")
pspectrum <- powspec(testsound@left, testsound@samp.rate)
aspectrum <- audspec(pspectrum, testsound@samp.rate)
cepstra <- spec2cep(aspectrum$aspectrum)
```

summary-methods *Object Summaries*

Description

summary is a generic function used to produce result summaries of the results of various model fitting functions. The function invokes particular methods which depend on the class of the first argument.

Methods

object = "ANY" Any object for which a summary is desired, dispatches to the S3 generic.

object = "Wave" The Wave object is being shown and an additional summary of the Wave-object's (one or two) channels is given.

object = "WaveMC" The WaveMC object is being shown and an additional summary of the WaveMC-object's channels is given.

object = "Wspec" The Wspec object is being shown and as an additional output is given: df, taper (see spectrum) and for the underlying Wave object the number of channels and its sampling rate.

object = "WspecMat" The WspecMat object is being shown and as an additional output is given: df, taper (see spectrum) and for the underlying Wave object the number of channels and its sampling rate.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

For the S3 generic: summary.default, plot-methods, Wave-class, Wave, WaveMC-class, WaveMC, Wspec, WspecMat, show

tuneR *tuneR*

Description

tuneR, a collection of examples

Functions in tuneR

tuneR consists of several functions to work with and to analyze Wave files. In the following examples, some of the functions to generate some data (such as `sine`), to read and write Wave files (`readWave`, `writeWave`), to represent or construct (multi channel) Wave files (`Wave`, `WaveMC`), to transform Wave objects (`bind`, `channel`, `downsample`, `extractWave`, `mono`, `stereo`), and to `play` Wave objects are used.

Other functions and classes are available to calculate several periodograms of a signal (`periodogram`, `Wspec`), to estimate the corresponding fundamental frequencies (`FF`, `FFpure`), to derive the corresponding notes (`noteFromFF`), and to apply a `smoother`. Now, the melody and corresponding energy values can be plotted using the function `melodyplot`.

A next step is the quantization (`quantize`) and a corresponding plot (`quantplot`) showing the note values for binned data. Moreover, a function called `lilyinput` (and a data-preprocessing function `quantMerge`) can prepare a data frame to be presented as sheet music by postprocessing with the music typesetting software LilyPond.

Of course, print (show), plot and summary methods are available for most classes.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de> with contributions from Sebastian Krey, Olaf Mersmann, Sarah Schnackenberg, Andrea Preusser, Anita Thieler, and Claus Weihs, as well as code fragments and ideas from the former package **sound** by Matthias Heymann and functions from 'rastamat' by Daniel P. W. Ellis. The included parts of the libmad MPEG audio decoder library are authored by Underbit Technologies.

Examples

```
library("tuneR") # in a regular session, we are loading tuneR

# constructing a mono Wave object (2 sec.) containing sinus
# sound with 440Hz and folled by 220Hz:
Wobj <- bind(sine(440), sine(220))
show(Wobj)
plot(Wobj) # it does not make sense to plot the whole stuff
plot(extractWave(Wobj, from = 1, to = 500))
## Not run:
play(Wobj) # listen to the sound

## End(Not run)

tmpfile <- file.path(tempdir(), "testfile.wav")
# write the Wave object into a Wave file (can be played with any player):
writeWave(Wobj, tmpfile)
# reading it in again:
Wobj2 <- readWave(tmpfile)

Wobjm <- mono(Wobj, "left") # extract the left channel
# and downsample to 11025 samples/sec.:
Wobjm11 <- downsample(Wobjm, 11025)
# extract a part of the signal interactively (click for left/right limits):
```

```
## Not run:
Wobjm11s <- extractWave(Wobjm11)

## End(Not run)
# or extract some values reproducibly
Wobjm11s <- extractWave(Wobjm11, from=1000, to=17000)

# calculating periodograms of sections each consisting of 1024 observations,
# overlapping by 512 observations:
WspecObject <- periodogram(Wobjm11s, normalize = TRUE, width = 1024, overlap = 512)
# Let's look at the first periodogram:
plot(WspecObject, xlim = c(0, 2000), which = 1)
# or a spectrogram
image(WspecObject, ylim = c(0, 1000))
# calculate the fundamental frequency:
ff <- FF(WspecObject)
print(ff)
# derive note from FF given diapason a'=440
notes <- noteFromFF(ff, 440)
# smooth the notes:
snotes <- smoother(notes)
# outcome should be 0 for diapason "a'" and -12 (12 halftones lower) for "a"
print(snotes)
# plot melody and energy of the sound:
melodyplot(WspecObject, snotes)

# apply some quantization (into 8 parts):
qnotes <- quantize(snotes, WspecObject@energy, parts = 8)
# an plot it, 4 parts a bar (including expected values):
quantplot(qnotes, expected = rep(c(0, -12), each = 4), bars = 2)
# now prepare for LilyPond
qlily <- quantMerge(snotes, 4, 4, 2)
qlily
```

`updateWave` *Update old Wave objects for use with new versions of tuneR*

Description

Update old Wave objects generated with **tuneR** < 1.0.0 to the new class definition for use with new versions of the package.

Usage

```
updateWave(object)
```

Arguments

`object`	An object of Wave-class.

Details

This function is only needed to convert Wave-class objects that have been saved with **tuneR** versions prior to 1.0-0 to match the new class definition.

Value

An object of Wave-class as implemented in **tuneR** versions >= 1.0-0.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg

See Also

Wave-class, Wave

Examples

```
x <- sine(440)
updateWave(x)
```

Wave *Constructors and coercion for class Wave objects*

Description

Constructors and coercion for class Wave objects

Usage

```
Wave(left, ...)
## S4 method for signature 'numeric'
Wave(left, right = numeric(0), samp.rate = 44100, bit = 16, pcm = TRUE, ...)
```

Arguments

left, right, samp.rate, bit, pcm	See Section "Slots" on the help page Wave-class. Except for numeric, the argument left can also be a matrix (1 or 2 columns), data.frame (1 or 2 columns), list (1 or 2 elements), or WaveMC (1 or 2 channels) object representing the channels.
...	Further arguments to be passed to the numeric method.

Details

The class definition has been extended in **tuneR** version 1.0-0. Saved objects of class Wave generated with former versions can be updated with updateWave to match the new definition.

Value

An object of Wave-class.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

Wave-class, WaveMC-class, writeWave, readWave, updateWave

Examples

```
# constructing a Wave object (1 sec.) containing sinus sound with 440Hz:
x <- seq(0, 2*pi, length = 44100)
channel <- round(32000 * sin(440 * x))
Wobj <- Wave(left = channel)
Wobj

# or more easily:
Wobj <- sine(440)
```

Wave-class *Class Wave*

Description

Class "Wave".

Details

The class definition has been extended in **tuneR** version 1.0-0. Saved objects of class Wave generated with former versions can be updated with updateWave to match the new definition.

Objects from the Class

Objects can be created by calls of the form new("Wave", ...), or more conveniently using the function Wave.

Slots

left: Object of class "numeric" representing the left channel.

right: Object of class "numeric" representing the right channel, NULL if mono.

stereo: Object of class "logical" indicating whether this is a stereo (two channels) or mono representation.

samp.rate: Object of class "numeric" - the sampling rate, e.g. 44100 for CD quality.

bit: Object of class "numeric", common is 16 for CD quality, or 8 for a rather rough representation.

pcm: Object of class "logical" indicating whether this is a PCM or IEEE_FLOAT Wave format.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

Wave, updateWave, and for multi channel Wave files see WaveMC-class

---

Waveforms *Create Wave Objects of Special Waveforms*

Description

Create a Wave object of special waveform such as silcence, power law (white, red, pink, ...) noise, sawtooth, sine, square, and pulse.

Usage

```
noise(kind = c("white", "pink", "power", "red"), duration = samp.rate,
      samp.rate = 44100, bit = 1, stereo = FALSE,
      xunit = c("samples", "time"), alpha = 1, ...)

pulse(freq, duration = samp.rate, from = 0, samp.rate = 44100,
      bit = 1, stereo = FALSE, xunit = c("samples", "time"),
      width = 0.1, plateau = 0.2, interval = 0.5, ...)

sawtooth(freq, duration = samp.rate, from = 0, samp.rate = 44100,
         bit = 1, stereo = FALSE, xunit = c("samples", "time"),
         reverse = FALSE, ...)

silence(duration = samp.rate, from = 0, samp.rate = 44100,
        bit = 1, stereo = FALSE, xunit = c("samples", "time"), ...)

sine(freq, duration = samp.rate, from = 0, samp.rate = 44100,
     bit = 1, stereo = FALSE, xunit = c("samples", "time"), ...)

square(freq, duration = samp.rate, from = 0, samp.rate = 44100,
       bit = 1, stereo = FALSE, xunit = c("samples", "time"),
       up = 0.5, ...)
```

Arguments

kind	The kind of noise, “white”, “pink”, “power”, or “red” (these are not dB adjusted (!) but all except for “white” are linear decreasing on a log-log scale). Algorithm for generating power law noise is taken from Timmer and König (1995).
freq	The frequency (in Hertz) to be generated.
duration	Duration of the Wave in xunit.

from	Starting value of the Wave in xunit.
samp.rate	Sampling rate of the Wave.
bit	Resolution of the Wave and rescaling unit. This may be 1 (default) for rescaling to numeric values in [-1,1], 8 (i.e. 8-bit) for rescaling to integers in [0, 254], 16 (i.e. 16-bit) for rescaling to integers in [-32767, 32767], 24 (i.e. 24-bit) for rescaling to integers in [-8388607, 8388607], 32 (i.e. 32-bit) for rescaling either to integers in [-2147483647, 2147483647] (PCM Wave format if pcm = TRUE) or to numeric values in [-1, 1] (FLOAT_IEEE Wave format if pcm = FALSE), 64 (i.e. 64-bit) for rescaling to numeric values in [-1, 1] (FLOAT_IEEE Wave format), and 0 for not rescaling at all. These numbers are internally passed to normalize. The Wave slot bit will be set to 32 if bit = 0, bit = 1 or bit = 32.
stereo	Logical, if TRUE, a stereo sample will be generated. The right channel is identical to the left one for sawtooth, silence, sine, and square. For noise, both channel are independent.
xunit	Character indicating which units are used (both in arguments duration and from). If xunit = "time", the unit is time in seconds, otherwise the number of samples.
alpha	The power for the power law noise (defaults are 1 for pink and 1.5 for red noise) $1/f^{\alpha}$.
reverse	Logical, if TRUE, the waveform will be mirrored vertically.
up	A number between 0 and 1 giving the percentage of the waveform at max value (= 1 - percentage of min value).
width	Relative pulses width: the proportion of time the amplitude is non-zero.
plateau	Relative plateau width: the proportion of the pulse width where amplitude is ±1.
interval	Relative interval between the up-going and down-going pulses with respect to the center of the wave period (0: immediatly after up-going, 1: center of the wave period).
...	Further arguments to be passed to Wave through the internal function postWaveform.

Value

A Wave object.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, partly based on code from Matthias Heymann's former package 'sound', Anita Thieler, Guillaume Guénard

References

J. Timmer and M. König (1995): On generating power law noise. Astron. Astrophys. 300, 707-710.

See Also

Wave-class, Wave, normalize, noSilence

Examples

```
Wobj <- sine(440, duration = 1000)
Wobj2 <- noise(duration = 1000)
Wobj3 <- pulse(220, duration = 1000)
plot(Wobj)
plot(Wobj2)
plot(Wobj3)
```

WaveMC *Constructors and coercion for class WaveMC objects*

Description

Constructors and coercion for class WaveMC objects

Usage

```
WaveMC(data, ...)
## S4 method for signature 'matrix'
WaveMC(data = matrix(numeric(0), 0, 0), samp.rate = 44100, bit = 16, pcm = TRUE, ...)
```

Arguments

data	Except for a numeric matrix, the argument data can also be a numeric vector (for one channel), data.frame (columns representing channels), list (elements containing numeric vectors that represent the channels), or Wave object.
samp.rate, bit, pcm	See Section "Slots" on the help page WaveMC-class.
...	Further arguments to be passed to the matrix method.

Value

An object of WaveMC-class.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg

See Also

WaveMC-class, Wave-class, writeWave, readWave

Examples

```
# constructing a WaveMC object (1 sec.) containing sinus sound with 440Hz:
x <- seq(0, 2*pi, length = 44100)
channel <- round(32000 * sin(440 * x))
WMCobj <- WaveMC(data = channel)
WMCobj
```

`WaveMC-class` *Class WaveMC*

Description

Class "WaveMC".

Details

This class has been added in **tuneR** version 1.0-0 for representation and construction of multi channel Wave files. Objects of class `Wave` can be transformed to the new class definition by calls of the form `as(..., "WaveMC")`. Coercion from the `WaveMC` class to the Wave-class works via `as(..., "Wave")` if there are no more than 2 channels. Coercing back to the Wave-class can be useful since some (very few) functions cannot yet deal with multi channel Wave objects.

Note that also the Wave-class definition has been extended in **tuneR** version 1.0-0. For more details see Wave-class.

Objects from the Class

Objects can be created by calls of the form `new("WaveMC", ...)`, or more conveniently using the function `WaveMC`.

Slots

`.Data`**:** Object of class `"matrix"` containing numeric data, where each column is representing one channel. Column names are the appropriate way to name different channels. The data object `MCnames` contains a data frame of standard names for channels in multi channel Wave files.

`samp.rate`**:** Object of class `"numeric"` - the sampling rate, e.g. 44100 for CD quality.

`bit`**:** Object of class `"numeric"`, common is 16 for CD quality, or 8 for a rather rough representation.

`pcm`**:** Object of class `"logical"` indicating whether this is a PCM or IEEE_FLOAT Wave format.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>, Sarah Schnackenberg

See Also

`WaveMC`, Wave-class, `MCnames`

WavPlayer *Getting and setting the default player for Wave files*

Description

Getting and setting the default player for Wave files

Usage

```
setWavPlayer(player)
getWavPlayer()
```

Arguments

player	Set the character string to call a Wave file player (including optional arguments) using options.

Value

getWavPlayer returns the character string that has been set by setWavPlayer.

Author(s)

Uwe Ligges <ligges@statistik.tu-dortmund.de>

See Also

Wave-class, Wave, play

writeWave *Writing Wave files*

Description

Writing Wave files.

Usage

```
writeWave(object, filename, extensible = TRUE)
```

Arguments

object	Object of class Wave or WaveMC to be written to a Wave file.
filename	Filename of the file to be written.
extensible	If TRUE (default), an extensible Wave format file is written. If FALSE, a non-extensible Wave file is written.

Details

It is only possible to write a non-extensible Wave format file for objects of class Wave or for objects of class WaveMC with one or two channels (mono or stereo).

If the argument object is a Wave-class object, the channels are automatically chosen to be "FL" (for mono) or "FL" and "FR" (for stereo).

The channel mask used to arrange the channel ordering in multi channel Wave files is written according to Microsoft standards as given in the data frame MCnames containing the first 18 standard channels. In the case of writing a multi channel Wave file, the column names of the object object (colnames(object)) must be specified and must uniquely identify the channel ordering for WaveMC objects. The column names of the object of class WaveMC have to be a subset of the 18 standard channels and have to match the corresponding abbreviated names. (See MCnames for possible channels and the abbreviated names: "FL", "FR", "FC", "LF", "BL", "BR", "FLC", "FRC", "BC", "SL", "SR", "TC", "TFL", "TFC", "TFR", "TBL", "TBC" and "TBR").

The function normalize can be used to transform and rescale data to an appropriate amplitude range for various Wave file formats (either pcm with 8-, 16-, 24- or 32-bit or IEEE_FLOAT with 32- or 64-bit).

Value

writeWave creates a Wave file, but returns nothing.

Author(s)

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See Also

Wave-class, Wave, WaveMC-class, WaveMC, normalize, MCnames, readWave

Examples

```
Wobj <- sine(440)

tdir <- tempdir()
tfile <- file.path(tdir, "myWave.wav")
writeWave(Wobj, filename = tfile)
list.files(tdir, pattern = "\\.wav$")
newWobj <- readWave(tfile)
newWobj
file.remove(tfile)
```

`Wspec-class` *Class Wspec*

Description

Class "Wspec" (*W*ave *spec*trums). Objects of this class represent a bunch of periodograms (see `periodogram`, each generated by `spectrum`) corresponding to one or several windows of one `Wave` or `WaveMC` object. Redundancy (e.g. same frequencies in each of the periodograms) will be omitted, hence reducing memory consumption.

Details

The subset function "`[`" extracts the selected elements of slots `spec`, `starts`, `variance` and `energy` and returns the other slots unchanged.

Objects from the Class

Objects can be created by calls of the form `new("Wspec", ...)`, but regularly they will be created by calls to the function `periodogram`.

Slots

The following slots are defined. For details see the constructor function `periodogram`.

`freq`: Object of class `"numeric"`.

`spec`: Object of class `"list"`.

`kernel`: Object of class `"ANY"`.

`df`: Object of class `"numeric"`.

`taper`: Object of class `"numeric"`.

`width`: Object of class `"numeric"`.

`overlap`: Object of class `"numeric"`.

`normalize`: Object of class `"logical"`.

`starts`: Object of class `"numeric"`.

`stereo`: Object of class `"logical"`.

`samp.rate`: Object of class `"numeric"`.

`variance`: Object of class `"numeric"`.

`energy`: Object of class `"numeric"`.

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See Also

- the show, plot and summary methods,
- for the constructor function and some examples: periodogram (and hence also spec.pgram, Wave-class, Wave, WaveMC-class, and WaveMC)
- WspecMat for a similar class that represents the spectrum in form of a matrix.

WspecMat-class *Class WspecMat*

Description

Class "WspecMat" (*W*ave *spec*trums as *Mat*rix). Objects of this class represent a bunch of periodograms (see periodogram, each generated by spectrum) corresponding to one or several windows of one Wave or WaveMC object. Redundancy (e.g. same frequencies in each of the periodograms) will be omitted, hence reducing memory consumption.

Details

The subset function "[" extracts the selected elements of slots spec, starts, variance and energy and returns the other slots unchanged.

Objects from the Class

Objects can be created by calls of the form new("WspecMat", ...), but regularly they will be created from a Wspec object by calls such as as(Wspec_Object, "WspecMat").

Slots

The following slots are defined. For details see the constructor function periodogram.

freq: Object of class "numeric".

spec: Object of class "matrix".

kernel: Object of class "ANY".

df: Object of class "numeric".

taper: Object of class "numeric".

width: Object of class "numeric".

overlap: Object of class "numeric".

normalize: Object of class "logical".

starts: Object of class "numeric".

stereo: Object of class "logical".

samp.rate: Object of class "numeric".

variance: Object of class "numeric".

energy: Object of class "numeric".

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See Also

the show, plot and summary methods

[-methods *Extract or Replace Parts of an Object*

Description

Operators act on objects to extract or replace subsets.

See Also

Extract for the S3 generic.

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