Package ‘spectral’

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Title A R package for carrying out the spectral analysis of univariate time series

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Depends R (>= 3.0), statmod

Description A R package for carrying out the spectral analysis of univariate time series

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URL http://www.r-project.org, http://www.stat.osu.edu/~pfc/

R topics documented:

`acvs.from.sdf` *Calculate the acvs via a Fourier transform of the SDF*

Description

Calculate the ACVS from lags 0 to lag 'max.lag', given a function specifying the SDF, 'the.sdf'.

Usage

```
acvs.from.sdf(max.lag, the.sdf, use.integrate = TRUE, num.weights = 200, gq, ...)
```

Arguments

`max.lag`	calculate the acvs from 0 to the lag 'max.lag'.
`the.sdf`	an R function defining the SDF
`use.integrate`	if use.integrate is TRUE use the 'integrate' function to calculate the integral. Otherwise use Gauss-Legendre quadrature from the 'statmod' library using the 'gq' object, if available, or creating a new object with 'num.weights' weights.
`num.weights`	the number of weights to use for the Gauss-Legendre quadrature
`gq`	a Gauss-Legendre quadrature from the 'statmod' library
`...`	Other arguments are passed to 'the.sdf' function

Value

a vector of max.lag+1 acvs values.

Author(s)

Peter F. Craigmile

`ar.sdf` *Calculate the spectral density function (SDF) for an AR process*

Usage

```
ar.sdf(freqs, phi, sigma2=1, delta.t=1)
```

Arguments

`freqs`	frequencies to evaluate the SDF at
`phi`	AR parameters
`sigma2`	innovation variance
`delta.t`	sampling interval

Value

vector of SDF values

Author(s)

Peter F. Craigmile

`ar2.example` *Coefficients for an example AR(2) process*

Usage

```
ar2.example
```

Format

A vector containing the coefficients of the AR(2) process.

Source

Equation 45 of Percival and Walden (1993).

References

Percival and Walden (1993) *Spectral Analysis for Physical Applications: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge University Press.

`ar4.example` *Coefficients for an example AR(4) process*

Usage

```
ar4.example
```

Format

A vector containing the coefficients of the AR(4) process.

Source

Equation 46a of Percival and Walden (1993).

References

Percival and Walden (1993) *Spectral Analysis for Physical Applications: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge University Press.

`arma.sdf` *Calculate the spectral density function (SDF) for an ARMA process*

Usage

```
arma.sdf(freqs, phi, theta, sigma2=1, delta.t=1)
```

Arguments

`freqs`	frequencies to evaluate the SDF at
`phi`	AR parameters
`theta`	MA parameters
`sigma2`	innovation variance
`delta.t`	sampling interval

Value

vector of SDF values

Author(s)

Peter F. Craigmile

arma.var.from.sdf — *Calculate the variance of an ARMA process using the spectral density function (SDF)*

Usage

```
arma.var.from.sdf(phi, theta, sigma2=1, delta.t=1)
```

Arguments

`phi`	AR parameters (may be omitted)
`theta`	MA parameters (may be omitted)
`sigma2`	innovation variance
`delta.t`	sampling interval

Value

variance of the ARMA process

Author(s)

Peter F. Craigmile

closest.Fourier.frequency — *Calculate closest Fourier frequency to a given frequency*

Usage

```
closest.Fourier.frequency(freq, N, delta.t=1)
```

Arguments

`freq`	frequency
`N`	length of times series
`delta.t`	sampling interval

Details

Calculates the closest Fourier frequency to 'freq', obtained when performing a spectral analysis on a time series of length 'N', with sampling interval 'delta.t'.

Author(s)

Peter F. Craigmile

`closest.Fourier.index` *Calculate closest Fourier index to a given frequency*

Usage

```
closest.Fourier.index(freq, N, delta.t=1)
```

Arguments

`freq`	frequency
`N`	length of times series
`delta.t`	sampling interval

Details

Calculates the closest Fourier index to 'freq', obtained when performing a spectral analysis on a time series of length 'N', with sampling interval 'delta.t'.

Author(s)

Peter F. Craigmile

`complex.chol` *Complex-valued Cholesky decomposition*

Usage

```
complex.chol(x,upper=TRUE)
```

Arguments

`x`	Matrix to calculate the complex-valued Cholesky of
`upper`	If true (the default), calculate the upper triangular form, if false calculate the lower triangular form.

Value

A matrix containing the complex-valued Cholesky decomposition in either the upper or lower triangular form.

Author(s)

Peter F. Craigmile

`cosine.taper` *Calculate a 100p% cosine taper*

Usage

```
cosine.taper(N, p)
```

Arguments

`N`	The length of the time series
`p`	A single numeric value between 0 and 1, inclusive

Value

A vector of length N containing the cosine (100p)% taper

Author(s)

Peter F. Craigmile

References

Percival and Walden (1993) *Spectral Analysis for Physical Applications: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge University Press, Equation 209.

`create.taper` *Create a spectral taper of a given type*

Usage

```
create.taper(taper.name, N, ...)
```

Arguments

`taper.name`	Name of the taper
`N`	Length of the taper
`...`	Extra arguments to pass to the taper

Value

A taper as a vector or matrix (if a multiple taper)

Author(s)

Peter F. Craigmile

`decibels` *Convert to decibels*

Description

Converts a numerical vector to the decibels value

Usage

```
decibels(x)
```

Arguments

`x`	a numerical vector

Value

The vector of x values converted to decibels

Author(s)

Peter F. Craigmile

Examples

```
decibels(1)  # return 0
decibels(10) # returns 10
decibels(0)  # return -Inf
```

`direct.spectral` *Direct spectral estimate*

Description

Calculate the tapered direct spectral estimate

Usage

```
direct.spectral(x, taper.name, delta.t=deltat(x), taper=create.taper(taper.name, length(x), ...)
```

Arguments

`x`	Time series object (the data)
`taper.name`	The name of the taper
`delta.t`	Sampling interval
`taper`	The taper
`...`	Optional arguments used to create the taper (if necessary)

Details

Calculate the tapered direct spectral estimate of a univariate time series of 'x'.

Value

An object of class 'spect' containing the direct spectral estimate of 'x' using the taper, 'taper'.

Author(s)

Peter F. Craigmile

`Dirichlet.kernel` *Calculate Dirichlet's kernel*

Usage

```
Dirichlet.kernel(freqs, N)
```

Arguments

`freqs`	frequencies to evaluate at
`N`	length of time series

Value

Dirichlet's kernel at the evaluated frequencies

Author(s)

Peter F. Craigmile

References

Equation 1.3c of Percival and Walden (1993)

`dpss.taper` *Calculate a set of dpss tapers*

Usage

```
dpss.taper(N, n.tapers, NW = 4, W = NW/N)
```

Arguments

`N`	The length of the time series
`n.tapers`	The number of tapers to calculate
`NW`	N times by the bandwidth, W
`W`	The bandwidth of the tapers, W

Value

If n.tapers is one then the first dpss taper of bandwidth W is returned as a vector. If n.tapers is greater than one, this function returns a matrix of dimension N by n.tapers. Each column of the matrix contains a different dpss taper.

Author(s)

Peter F. Craigmile

References

Percival and Walden (1993) *Spectral Analysis for Physical Applications: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge University Press.

`Fejer.kernel` *Calculate Fejer's kernel*

Usage

```
Fejer.kernel(freqs, N, delta.t=1)
```

Arguments

`freqs`	frequencies to evaluate at
`N`	length of time series
`delta.t`	sampling interval

Value

Fejer's kernel at the evaluated frequencies

Author(s)

Peter F. Craigmile

References

Equation 198b of Percival and Walden (1993) `fft1` *Calculate fft of a vector using a starting time index of 1*

Usage

```
fft1(x)
```

Arguments

`x`	a numerical vector

Value

Calculates

$$J(k/n) = \sum_{t=1}^{n} x_t \, e^{-i2\pi(k/n)t}$$

for $k = 0, ..., (n-1)$, where n=length(x)

Author(s)

Peter F. Craigmile

`Fisher.test` *Fisher's test for an unknown periodicity*

Usage

```
Fisher.test(sp, alpha=.05)
```

Arguments

`sp`	Spectral object to analyze.
`alpha`	Size of the test.

Value

hypothesis test ('h.test') object containing the results of Fisher's test for an unknown periodicity.

Author(s)

Peter F. Craigmile

References

Percival and Walden (1993) *Spectral Analysis for Physical Applications: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge University Press, Section 10.9.

`Fourier.frequencies` *Calculate all the Fourier frequencies*

Usage

```
Fourier.frequencies(N, delta.t=1)
```

Arguments

`N`	length of times series
`delta.t`	sampling interval

Details

Calculates all the Fourier frequencies obtained when performing spectral analysis on a time series of length 'N', with sampling interval 'delta.tt'.

Author(s)

Peter F. Craigmile

`h` *Calculate the Hermitian transpose of a matrix*

Usage

```
h(x)
```

Arguments

`x`	a matrix

Value

a matrix, containing the Hermitian transpose of 'x'.

Author(s)

Peter F. Craigmile

`Hanning.taper` *Calculate a Hanning taper*

Usage

```
Hanning.taper(N)
```

Arguments

`N`	The length of the time series

Details

The Hanning taper is the same as a 100% cosine taper

Value

A vector of length N containing the Hanning taper

Author(s)

Peter F. Craigmile

References

Percival and Walden (1993) *Spectral Analysis for Physical Applic ations: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge Univ ersity Press, Page 210.

`idecibels` *Convert from decibels*

Description

Converts a numerical vector from the decibels value

Usage

```
idecibels(x)
```

Arguments

`x`	a numerical vector

Value

The vector of x values converted from decibels to the original scale

Author(s)

Peter F. Craigmile

Examples

```
idecibels(0)  # return 1
idecibels(10) # returns 10
idecibels(-Inf)  # return 0
```

---

ma.sdf *Calculate the spectral density function (SDF) for an MA process*

Usage

```
ma.sdf(freqs, theta, sigma2=1, delta.t=1)
```

Arguments

`freqs`	frequencies to evaluate the SDF at
`theta`	MA parameters
`sigma2`	innovation variance
`delta.t`	sampling interval

Value

Vector of SDF values

Author(s)

Peter F. Craigmile

---

mean.spect *Spectral Mean*

Description

Average multiply tapered spectral estimates

Usage

```
## S3 method for class spect
mean(x, ...)
```

Arguments

`x`	an item of class 'spect'
`...`	Extra arguments from the 'mean' function'

Details

Average the different spectra in the spect class 'sp' (normally used for multitapering).

Value

An object of class 'spect' which contains the averaged spectra.

Author(s)

Peter F. Craigmile

`multitaper.effective.bw` *Calculate the effective bandwidth of a set of multitapers*

Usage

```
multitaper.effective.bw(tapers)
```

Arguments

`tapers`	a matrix of multitapers

Author(s)

Peter F. Craigmile

`periodicity` *Generate periodicity*

Usage

```
periodicity(N, amps, freqs, phases, delta.t)
```

Arguments

`N`	The length of the time series to generate.
`amps`	A vector of amplitudes.
`freqs`	A vector of frequencies.
`phases`	A vector of phases (default is to generate from Uniform[$-\pi$,π])
`delta.t`	The sampling interval (The default is 1).

Value

The periodocity

Author(s)

Peter F. Craigmile

periodogram *Periodogram*

Description

Calculate periodogram

Usage

```
periodogram(x, delta.t=deltat(x))
```

Arguments

`x`	Time series object (the data)
`delta.t`	Sampling interval

Details

Calculate the periodogram of a univariate time series of 'x'.

Value

An object of class 'spect' containing the periodogram of 'x'.

Author(s)

Peter F. Craigmile

plot.spect *plot.spect*

Usage

```
## S3 method for class spect
plot(x, taper.num, xlab="Frequency", ylab="Spectrum",
   log.freq=FALSE, add=FALSE, type="l", ...)
```

Arguments

`x`	an object of class 'spect'
`taper.num`	if 'x' contains many tapers, which taper to show.
`xlab`	x label for the figure
`ylab`	y label for the figure
`log.freq`	if TRUE present the figure on the log frequency scale
`add`	if TRUE add to current plot, otherwise create new plot
`type`	line type is used by default in this figure
`...`	further arguments that can be passed to the plot

Details

Plot the object 'sp' of class 'spect' in decibels, showing frequencies on the log scale if log.freq=T.

Value

No value is returned

Author(s)

Peter F. Craigmile

`rectangular.taper` *Calculate a rectangular taper*

Usage

```
rectangular.taper(N)
```

Arguments

`N`	The length of the time series

Details

The rectangular taper is the same a 0% cosine taper

Value

A vector of length N containing the rectangular taper

Author(s)

Peter F. Craigmile

References

Percival and Walden (1993) *Spectral Analysis for Physical Applic ations: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge Univ ersity Press, Page 209.

`renormalize.taper` *Renormalize the taper so that it has unit norm*

Usage

```
renormalize.taper(taper)
```

Arguments

`taper`	The taper

Value

The taper renormalized to have unit norm

Author(s)

Peter F. Craigmile

`sine.taper` *Calculate a set of sine tapers*

Usage

```
sine.taper(N, n.tapers)
```

Arguments

`N`	The length of the time series
`n.tapers`	The number of tapers to calculate

Value

If n.tapers is one then the single sine taper is returned as a vector. If n.tapers is greater than one, this function returns a matrix of dimension N by n.tapers. Each column of the matrix contains a different sine taper.

Author(s)

Peter F. Craigmile

References

Percival and Walden (1993) *Spectral Analysis for Physical Applications: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge University Press.

`spect`	*Create a object of class 'spect'*

Usage

```
spect(spec, N, delta.t=1)
```

Arguments

`spec`	a numerical vector
`N`	length of the original time series
`delta.t`	sampling interval

Details

Create a class of type 'spect' from a spectrum 'spec'of a time series of length 'N' regularly sampled at rate 'delta.t'.

Value

An object of class 'spect' which contains the frequencies 'freq', spectral estimates 'spec', sampling interval 'delta.t', sample size 'N' and number of Fourier frequencies, 'n.Fourier'.

Author(s)

Peter F. Craigmile

`spect.max`	*The frequency of maximum spectrum*

Usage

```
spect.max(sp, f1, f2)
```

Arguments

`sp`	object of class 'spect'
`f1`	lower bound of the frequency
`f2`	upper bound of the frequency

Value

The frequency between 'f1' and 'f2' which has highest spectrum in the 'sp'.

Author(s)

Peter F. Craigmile

`squared.gain` *Calculate the squared gain function*

Usage

```
squared.gain(fs, filter, multiplier=1, use.C=TRUE)
```

Arguments

`fs`	a numerical vector of frequencies
`filter`	a vector of filter coefficients
`multiplier`	a multipler for the frequencies
`use.C`	if use.C is TRUE use C code to calculate; otherwise using R code

Details

Calculate the squared gain function for the ’filter’ at the frequencies ’multiplier * fs’.

Value

A numerical vector of squared gain function values, the same length as ’fs’.

Author(s)

Peter F. Craigmile

`Thomson.crit` *Critical value of Thomson’s F test*

Usage

```
Thomson.crit(n.tapers, alpha)
```

Arguments

`n.tapers`	The number of tapers
`alpha`	The alpha value to evaluate critical value

Value

alpha’th critical value

Author(s)

Peter F. Craigmile

References

Percival and Walden (1993) *Spectral Analysis for Physical Applications: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge University Press, Section 10.11.

`Thomson.stat` *Thomson's F statistic*

Usage

```
Thomson.stat(x, index, tapers, n.tapers)
```

Arguments

`x`	The time series of interest
`index`	The Fourier index to test at
`tapers`	The matrix of tapers to use for the test
`n.tapers`	The number of tapers to evaluate

Details

Perform Thomson's F test to test for a non-zero amplitude at Fourier index 'index' in the time series 'x' using 'n.tapers' tapers from the matrix of tapers 'tapers'.

Value

The F statistic of Thomson's F test

Author(s)

Peter F. Craigmile

References

Percival and Walden (1993) *Spectral Analysis for Physical Applications: Multitaper and Conventional Univariate Techniques*. Cambridge: Cambridge University Press, Section 10.11.

`transfer` *Calculate the transfer function*

Usage

```
transfer(fs, filter)
```

Arguments

`fs`	a numerical vector of frequencies
`filter`	a vector of filter coefficients

Details

Calculate the transfer function for the 'filter' at the frequencies 'fs'.

Value

A numerical vector of transfer function values, the same length as 'fs'.

Author(s)

Peter F. Craigmile

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