Package 'spectral'

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

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

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

R topics documented:

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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,
```

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

---

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$[-\pi, \pi]$)
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

`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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