Package ‘lomb’

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Description Computes the Lomb-Scargle Periodogram for unevenly sampled time series. Includes a randomization procedure to obtain exact p-values.
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Description

The Lomb-Scargle periodogram is the most widely used method to detect even weak periodic components in unequally sampled time series. It can also be used for equally sampled time series.

Details

| Package: | lomb |
| Type:    | Package |
| Version: | 2.1.0 |
| Date:    | 2022-02-22 |
| License: | GPL-3 |

Function `lsp` computes the Lomb-Scargle periodogram for unevenly sampled times series (e.g., series with missing data). P-values for the highest peak in the periodogram are computed from the exponential distribution. Alternatively, function `randlsp` computes a p-value for the largest peak in the periodogram by repeatedly randomising the time-series sequence. Both functions allow setting the range of frequencies to be inspected, as well as the stepsize (oversampling factor) used for frequency scanning.

Author(s)

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References


Examples

data(lynx)
lsp(lynx)
getpeaks

Get periodogram peaks

Description

Retrieves and displays the npeaks largest peaks in the periodogram.

Usage

getpeaks(object, npeaks, plotit)

Arguments

object
  object must be of class "lsp"

npeaks
  number of peaks to get

plotit
  if TRUE show plot

Value

Returns a list with

data
  A dataframe with times an heights of peaks

plot
  An annotated periodogram

Author(s)

Thomas Ruf <thomas.ruf@vetmeduni.ac.at>

See Also

show

Examples

per = lsp(lynx, ofac=5)
getpeaks(per, 6) # obtain the 6 largest peaks
ggamma

Utility function called by pbaluev()

Description

From astropy.timeseries

Usage

ggamma(N)

Arguments

N  A positive number

Value

sqrt(2 / N) * exp(lgamma(N / 2) - lgamma((N - 1) / 2))

Author(s)

Thomas Ruf <thomas.ruf@vetmeduni.ac.at>.

References


See Also

pbaluev

Examples

ggamma(3)
**ibex**  

*Rumen Temperature In An Alpine Ibex*

**Description**

Telemetric measurements of rumen temperature in a free-living alpine ibex (*Capra ibex*) measured at unequal time intervals.

**Usage**

```
data(ibex)
```

**Format**

A data frame with 1201 observations on 3 variables.

- **date**: a character variable giving date and time of measurements.
- **hours**: a numerical variable giving hours elapsed since the first measurement.
- **temp**: a numerical variable giving rumen (stomach) temperature in degrees Celsius.

**Source**


**Examples**

```
data(ibex)
datetime <- as.POSIXlt(ibex$date)
plot(datetime, ibex$temp, pch=19, cex=0.3)
```

**levopt**  

*compute level*

**Description**

utility function to determine deviation from p-value

**Usage**

```
levopt(x, alpha, fmax, tm)
```

**Arguments**

- **x**
- **alpha**
- **fmax**
- **tm**
Value

\[(\log(\text{prob})-\log(\alpha))^2\]

Author(s)

Thomas Ruf <thomas.ruf@vetmeduni.ac.at>.

---

**lsp**  
*Lomb-Scargle Periodogram*

**Description**

Computes the Lomb-Scargle periodogram for a time series with irregular (or regular) sampling intervals. Allows selecting a frequency range to be inspected, as well as the spacing of frequencies scanned.

**Usage**

\[
lsp(x, \text{times} = \text{NULL}, \text{from} = \text{NULL}, \text{to} = \text{NULL}, \text{type} = \text{c("frequency", "period")}, \text{ofac} = 1, \alpha = 0.01, \text{normalize} = \text{c("standard", "press")}, \text{plot} = \text{TRUE}, \ldots)
\]

**Arguments**

- **x**: The data to be analysed. x can be either a two-column numerical dataframe or matrix, with sampling times in column 1 and measurements in column 2, a single numerical vector containing measurements, or a single vector ts object (which will be converted to a numerical vector).
- **times**: If x is a single vector, times can be provided as a numerical vector of equal length containing sampling times. If x is a vector and times is NULL, the data are assumed to be equally sampled and times is set to 1:length(x).
- **from**: The starting frequency (or period, depending on type) to begin scanning for periodic components.
- **to**: The highest frequency (or period, depending on type) to scan.
- **type**: Either “frequency” (the default) or “period”. Determines the type of the periodogram x-axis.
- **ofac**: The oversampling factor. Must be an integer\(\geq 1\). Larger values of ofac lead to finer scanning of frequencies but may be time-consuming for large datasets and/or large frequency ranges (from...to).
- **alpha**: The significance level. The periodogram plot shows a horizontal dashed line. Periodogram peaks exceeding this line can be considered significant at alpha. Defaults to 0.01. Only used if plot=TRUE.
normalize The type of normalization used, either “standard” or “press”. If normalization is standard (the default) the periodogram is confined to the interval 0-1, and the statistical significance of the largest peak in the periodogram is computed according to Baluev (2008). If normalization is set to “press” the periodogram will be normalized using the factor 1/(2 * var(y)) and the p-value for the significance of the largest peak in the periodogram is computed from the exponential distribution, as outlined in Press et al. (1994), see below.

plot Logical. If plot=TRUE the periodogram is plotted.

... Further graphical parameters affecting the periodogram plot.

Details

For a more robust - but potentially time-consuming estimation of p-values (when n is large) see randlsp.

Significance levels in both lsp and randlsp increase with the number of frequencies inspected. Therefore, if the frequency-range of interest can be narrowed down a priori, use arguments “from” and “to” to do so.

Value

A named list with the following components:

normalize The type of normalization used.
scanned A vector containing the frequencies/periods scanned.
power A vector containing the normalised power corresponding to scanned frequencies/periods.
data Names of the data vectors analysed.
n The length of the data vector.
type The periodogram type used, either “frequency” or “period”.
ofac The oversampling factor used.
n.out The length of the output (powers). This can be >n if ofac >1.
alpha The false alarm probability used.
sig.level Powers > sig.level can be considered significant peaks at p=alpha.
peak The maximum power in the frequency/period interval inspected.
peak.at The frequency/period at which the maximum peak occurred.
p.value The probability that the maximum peak occurred by chance.

Note

Author(s)

Thomas Ruf <thomas.ruf@vetmeduni.ac.at> based on code by Press et al (1994).

References


See Also

randlsp summary.lsp

Examples

# ibex contains an unevenly sampled time series
data(ibex)
lsp(ibex[,2:3],ofac=5)
lsp(ibex$temp,times=ibex$hours,type='period',ofac=5)

# lynx contains evenly sampled data
lsp(lynx)
lynx.spec <- lsp(lynx,type='period',from=2,to=20,ofac=5)
summary(lynx.spec)

# generate unevenly sampled data
time=(runif(200,1,1000))
y=2*cos(time/6)+rnorm(200,0,4)
lsp(y,times=time,ofac=10, to=0.3)
pbaluev

False alarm probability

Description
Computes the statistical significance of peaks (range 0-1) in the standardized periodogram. Typically not called by the user.

Usage
pbaluev(Z,fmax,tm)

Arguments
Z    the height of a periodogram peak
fmax the highest frequency inspected
tm   a vector with measurement timepoints

Details
Based on results in extreme value theory, improved analytic estimations of false alarm probabilities are given.

Value
Returns the significance of the largest peak in the periodogram.

Note
Code based on astropy.timeseries

Author(s)
Thomas Ruf <thomas.ruf@vetmeduni.ac.at>.

References

See Also
summary.lsp

Examples
pbaluev(0.19,2.0,1:100)
pershow  

Description

Shows a periodogram in browser window as line and dot plot. When moving the cursor close to dots times an peak-heights of the periodogram are shown.

Usage

pershow(object) \# object of class \"lsp\"

Arguments

object

Author(s)

Thomas Ruf <thomas.ruf@vetmeduni.ac.at>

See Also

getpeaks

Examples

per=lsp(lynx,ofac=5)
pershow(per)

plot.lsp  

Plot Lomb-Scargle Periodogram

Description

Plots the normalised power as a function of frequency (or period, depending on type in function lsp).

Usage

## S3 method for class \'lsp\'
plot(x, main = \"Lomb-Scargle Periodogram\", xlabel = NULL,
     ylabel = \"normalized power\", level = TRUE, plot=TRUE, ...)

plot.lsp
Arguments

- **x**: Object of class lsp as returned from function lsp.
- **main**: Character. Main title of the periodogram plot. Defaults to “Lomb-Sargle Periodogram”.
- **xlabel**: Character. X-axis label of the periodogram plot.
- **ylabel**: Character. Y-axis label of the periodogram plot.
- **level**: Logical. If TRUE, the significance level is displayed as a dashed line.
- **plot**: If TRUE, the periodogram is plotted.
- **...**: Additional graphics parameters

Details

Usually, this function is only called by function lsp. It maybe called by the user for some control of the output. For better control, plot results from lsp ($scanned$, $power$) as desired.

Value

Invisibly returns the object of class lsp it is called with.

Author(s)

Thomas Ruf <thomas.ruf@vetmeduni.ac.at>

See Also

- **lsp**

Examples

```r
data(ibex)
ibex.spec <- lsp(ibex[,2:3], type='period', from=12, to=36, ofac=10, plot=FALSE)
plot.lsp(ibex.spec, main="Tb in Capra ibex", xlabel="Period (h)", ylabel="Power", level=FALSE)
```

---

**Description**

`randlsp` is used to obtain robust p-values for the significance of the largest peak in a Lomb-Scargle periodogram by randomisation. The data sequence is scrambled repeatedly and the probability of random peaks reaching or exceeding the peak in the original (unscrambled) periodogram is computed.
Usage

randlsp(repeats=1000, x, times = NULL, from = NULL, to = NULL,
        type = c("frequency", "period"), ofac = 1, alpha = 0.01,
        plot = TRUE, trace = TRUE, ...)

Arguments

repeats  An integer determining the number of repeated randomisations. Large numbers
         (>=1000) are better but can make the procedure time-consuming.

x        The data to be analysed. x can be either a two-column numerical dataframe or
         matrix, with sampling times in column 1 and measurements in column 2, a
         single numerical vector containing measurements, or a single vector ts object
         (which will be converted to a numerical vector).

times    If x is a single vector, times can be provided as a numerical vector of equal
         length containing sampling times. If x is a vector and times is NULL, the data
         are assumed to be equally sampled and times is set to 1:length(x).

from     The starting frequency (or period, depending on type) to begin scanning for
         periodic components.

to       The highest frequency (or period, depending on type) to scan.

type     Either “frequency” (the default) or “period”. Determines the type of the peri-
         ogram x-axis.

ofac     The oversampling factor. Must be an integer >=1. Larger values of ofac lead
         to finer scanning of frequencies but may be time-consuming for large datasets
         and/or large frequency ranges (from...to).

alpha    The significance level. The periodogram plot shows a horizontal dashed line.
         Periodogram peaks exceeding this line can be considered significant at alpha.
         Defaults to 0.01. Only used if plot=TRUE.

plot     Logical. If TRUE, two plots are displayed (i) The periodogram of the original
         (unscrambled) data (ii) A histogram of peaks occurring by chance during se-
         quence randomisation. A vertical line is drawn at the height of the peak in a
         periodogram of the original data.

trace    Logical. If TRUE, information about the progress of the randomisation proce-
         dure is printed during the running of randlsp.

...      Additional graphical parameters affecting the histogram plot.

Details

Function randlsp preserves the actual measurement intervals, which may affect the periodogram
(see Nemec & Nemec 1985, below). Hence, this is a conservative randomisation procedure.

P-values from both randlsp and lsp increase with the number of frequencies inspected. Therefore,
if the frequency-range of interest can be narrowed down a priori, use arguments “from” and “to” to
do so.
Value

A named list with the following items:

- `scanned`: A vector containing the frequencies/periods scanned.
- `power`: A vector containing the normalised power corresponding to scanned frequencies/periods.
- `data`: Names of the data vectors analysed.
- `n`: The length of the data vector.
- `type`: The periodogram type used, either “frequency” or “period”.
- `ofac`: The oversampling factor used.
- `n.out`: The length of the output (powers). This can be >n if ofac >1.
- `peak`: The maximum power in the frequency/period interval inspected.
- `peak.at`: The frequency/period at which the maximum peak occurred.
- `random.peaks`: A vector of peaks (with length=repeats) of maximum power values computed from randomised data.
- `repeats`: The number of randomisations.
- `p.value`: The probability that the peak in the original data occurred by chance, computed from randomising the data sequence.

Author(s)

Thomas Ruf <thomas.ruf@vetmeduni.ac.at>

References


See Also

- `lsp`

Examples

```r
data(lynx)
set.seed(444)
rand.times <- sample(1:length(lynx),30)  # select a random vector of sampling times
randlsp(repeats=1000, lynx[rand.times], times=rand.times)
```
Summary method for class `lsp`.

### Usage

```r
## S3 method for class 'lsp'
summary(object, ...)
```

### Arguments

- `object`: an object of class `lsp`.
- `...`: currently, no other arguments are required.

### Value

`summary.lsp` returns a one column data.frame with results from function `lsp`. Row names and contents are as follows:

- **Time**: Name of the sampling time variable.
- **Data**: Name of the measured variable.
- **Type**: either “frequency” or “period”.
- **Oversampling factor**: The degree of oversampling (>=1).
- **From**: The lowest frequency (or period, depending on type) inspected.
- **To**: The highest frequency (or period, depending on type) inspected.
- **# frequencies**: The number of frequencies (or periods, depending on type) inspected.
- **PNmax**: The peak normalised power in the periodogram.
- **At frequency**: The frequency at which PNmax occurred.
- **At period**: The period at which PNmax occurred.
- **P-value (PNmax)**: The probability that PNmax occurred by chance, computed from the exponential distribution.

### Author(s)

Thomas Ruf <thomas.ruf@vetmeduni.ac.at>

### See Also

- `lsp`


**summary.randlsp**

**Examples**

```r
data(lynx)
summary(lsp(lynx))
```

---

**summary.randlsp**

*Summarise Randomised Lomb-Scargle Periodogram Results*

**Description**

Summary method for class randlsp.

**Usage**

```r
## S3 method for class 'randlsp'
summary(object,...)
```

**Arguments**

- `object`: an object of class randlsp.
- `...`: currently, no other arguments are required.

**Value**

`summary.randlsp` returns a one column data.frame with results from function randlsp. Row names and contents are as follows:

- **Time**: Name of the sampling time variable.
- **Data**: Name of the measured variable.
- **Type**: either “frequency” or “period”.
- **Oversampling**: The degree of oversampling ($\geq 1$).
- **From**: The lowest frequency (or period, depending on type) inspected.
- **To**: The highest frequency (or period, depending on type) inspected.
- **# frequencies**: The number of frequencies (or periods, depending on type) inspected.
- **PNmax**: The peak normalised power in the periodogram.
- **At frequency**: The frequency at which PNmax occurred.
- **At period**: The period at which PNmax occurred.
- **Repeats**: The number of randomisations.
- **P-value (PNmax)**: The probability that PNmax occurred by chance, computed from randomising the data sequence.

**Author(s)**

Thomas Ruf <thomas.ruf@vetmeduni.ac.at>
See Also

`randlsp`

Examples

```r
data(lynx)
summary(randlsp(repeats=500,lynx))
```

---

**theme_lsp**  
_lsp theme for ggplot2_

Description

Import _lsp_ _ggplot2_ theme. It builds on _theme_bw_.

Usage

```r
theme_lsp(bs=18)
```

Arguments

- **bs**: basesize of font

Value

A theme element

Examples

```r
plot(lsp(lynx))+theme_lsp(25)
```
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