Package ‘nlts’

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Title (non)linear time series analysis

Description R functions for (non)linear time series analysis. A core topic is order estimation through cross-validation.

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X-CRAN-Comment Earlier versions of this package have been removed as they contained material not licensed under 'GPL'.

Repository CRAN

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R topics documented:

`add.test` *The Lagrange multiplier test for additivity in a timeseries*

Description

add.test is a function to test the permissibility of the additive autoregressive model:

N(t) = f1(N(t-1)) + f2(N(t-2)) + ... + fd(N(t-d)) + e(t)

against the alternative:

N(t) = F(N(t-1), N(t-2), ..., N(t-d)) + e(t)

Usage

```
add.test(x, order, n.cond = FALSE)
```

Arguments

`x`	A time series (vector without missing values).
`order`	a scalar representing the order to be considered.
`n.cond`	The number of observation to condition on. The default is `order` (must be >= `order`).

Details

This is the Lagrange multiplier test for additivity developed by Chen et al. (1995: test II).

The function requires the `acepack`-library.

Value

a vector is returned consisting of the asymtpotic chi-square value, the associated d.f. and asymptotic p.val for the test of additivity.

Author(s)

Ottar N. Bjornstad <onb1@psu.edu>

References

Chen, R., Liu, J.S. & Tsay, R.S. (1995) Additivity tests for nonlinear autoregression. Biometrika, 82, 369-383.

Bjornstad, O.N., Begon, M., Stenseth, N.C., Falck, W., Sait, S.M., & Thompson, D.J. (1998) Population dynamics of the Indian meal moth: demographic stochasticity and delayed regulatory mechanisms. Journal of Animal Ecology, 67, 110-126.

Examples

```
data(plodia)
add.test(sqrt(plodia), order = 3)
```

---

contingency.periodogram

The contingency periodogram for periodicity in categorical time series

---

Description

A funcion to estimate the contingency periodogram to test for periodicity in categorical time series.

Usage

```
contingency.periodogram(x, maxper = 6)
```

Arguments

`x`	A vector representing the categorical time series.
`maxper`	the maximum lag (period) considered.

Details

This is the contingency periodogram of Pierre Legedre and Pierre Dutielle to test for periodicity in categorical time series. I have coded the function so as to provide both the Fisher exact test and the asymptotic chi-square test.

Value

An object of class "contingency.periodogram" is returned consisting of a matrix with a row for each period considered. The columns are:

`exact.p`	the fischer exact test at each lag.
`chi-val`	the asymptotic chi-square value.
`df`	the chi-square degrees-of-freedom.
`asympt.p`	the chi-squared asymptotic p-value.

Author(s)

Ottar N. Bjornstad `<onb1@psu.edu>`

References

Legendre et al. (1981) The contingency periodogram: A method for identifying rhytms in series of nonmetric ecological data. Journal of Ecology, 69, 965-979.

See Also

`plot.contingency.periodogram`

Examples

```
data(plodia)
data<-as.factor((scale(plodia) > 0))
fit <- contingency.periodogram(data, maxper = 9)
## Not run: plot.contingency.periodogram(fit)
```

`lin.order.cls` *The order of a time series using cross-validation of the linear autoregressive model (conditional least-squares).*

Description

A function to estimate the order of a time series using cross-validation of the linear autoregressive model. Coefficients are estimated using conditional least-squares.

Usage

```
lin.order.cls(x, order=1:5, n.cond = 5, echo = TRUE)
```

Arguments

`x`	A time series without missing values
`order`	The candidate orders. The default is 1:5.
`n.cond`	The number of observation to condition on. The default is 5 (must be >= max(order)).
`echo`	if TRUE a counter for the data points and the orders is produced to monitor progress.

Details

The time series is normalized prior to cross-validation.

Note that if the dynamics is highly nonlinear, the nonparametric order-estimators (`ll.order`) may be more appropriate. (I coded this function to use for comparison with the nonparametric methods, because these also uses (nonlinear) conditional least-squares.)

Value

An object of class "lin.order" is returned consisting of the following components:

`order`	the grid of orders considered.
`CVd`	the cross-validation errors across the grid of orders.

Author(s)

Ottar N. Bjornstad <onb1@psu.edu>

See Also

`summary.lin.order` `plot.lin.order` `ll.order`

Examples

```
data(plodia)
fit <- lin.order.cls(sqrt(plodia), order=1:5)
## Not run: plot.lin.order(fit)
summary.lin.order(fit)
```

`lin.test` *A Tukey one-degree-of-freedom test for linearity in time series.*

Description

a function to test the permissibility of the linear autoregressive model:

N(t) = a0 + a1N(t-1) + a2N(t-2) + ... + adN(t-d) + e(t)

against the alternative:

Nt = F(N(t-1), N(t-2), ..., N(t-d)) + e(t)

Usage

```
lin.test(x, order)
```

Arguments

`x`	A time series (vector without missing values).
`order`	a scalar representing the order to be considered.

Details

This is the Tukey one-degree-of-freedom test of linearity developed by Tsay (1986). Orders up to 5 is permissible. [although the code is easily extended].

Value

A vector is returned consisting of the asymtpotic F-value, the associated numerator and denominator d.f.'s and asymptotic p.val for the test of linearity

Author(s)

Ottar N. Bjornstad <onb1@psu.edu>

References

Tsay, R.S. (1986) Nonlinearity tests for time series. Biometrika, 73, 461-466.

See Also

`plot.contingency.periodogram`

Examples

```
data(plodia)
lin.test(sqrt(plodia), order = 3)
```

`ll.order` *Consistent nonlinear estimate of the order using local polynomial regression.*

Description

A function to estimate the order of a time series using the nonparametric order selection method of Cheng and Tong (1992, 1994) as modified by Yao & Tong (1994; see also Fan, Yao & Tong 1996). The method uses leave-one-out cross-validation of the locally linear regression against lagged-abundances.

Usage

```
ll.order(x, order = 1:5, step = 1, deg = 2, bandwidth = c(seq(0.3,
1.5, by = 0.1), 2:10), cv = TRUE, echo = TRUE)
```

Arguments

`x`	A time series without missing values.
`order`	The candidate orders. The default is 1:5.
`step`	The time step for predicition.
`deg`	The degree of the local polynomial.
`bandwidth`	The candidate bandwidths to be considered.
`cv`	if TRUE leave-one-out crossvalidation will be performed.
`echo`	if TRUE a counter shows the progress

Details

The time series is normalized prior to cross-validation.

A Gaussian kernel is used for the locally linear regression.

The bandwidth is optimized using crossvalidation. If a single bandwidth is provided, no cross validation of bandwidth will be carried out. Highly nonlinear data will require more narrow bandwidths. If NA is returned it may be because the min bandwidth considered is too small relative to the density of data.

Missing values are NOT permitted.

If `deg` is set to 0, the order is estimated on the basis of the Nadaraya-Watson (locally constant) estimator of the conditional expecation against lagged-abundances (Cheng and Tong 1992, 1994). The function subsumes the `nw.order` of the previous S-plus nlt-library.

The function requires Loader's `locfit`-library.

Value

An object of class "ll.order" is returned consisting of the following components:

`grid`	the grid of orders, bandwidths, and CV's.
`grid$order`	the orders.
`grid$CV`	the cross-validation score across the grid of orders and bandwidths. (If `cv = TRUE`).
`grid$GCV`	the generalized cross-validation score.
`grid$bandwidth`	the bandwidths.
`grid$df`	the degrees of freedom of the fitted model.
`order`	the vector of orders considered.
`deg`	The degree of the local polynomial.

Author(s)

Ottar N. Bjornstad <onb1@psu.edu>

References

Cheng, B. & Tong, H. (1992) On consistent nonparametric order determination and chaos. Journal of Royal Statistical Society B, 54, 427-449.

Cheng, B. & Tong, H. (1994) Orthogonal projection, embedding dimension and sample size in chaotic time series from a statistical perspective. Philosophical Transactions of the Royal Society London, A. , 348, 325-341.

Fan, J., Yao, Q., & Tong, H. (1996) Estimation of conditional densities and sensitivity measures in nonlinear dynamical systems. Biometrika, 83, 189-206.

Yao, Q. & Tong, H. (1994) Quantifying the influence of initial values on non-linear prediction. Journal of Royal Statistical Society B, 56, 701-725.

Bjornstad, O.N., Sait, S.M., Stenseth, N.C., Thompson, D.J., & Begon, M. (2001) Coupling and the impact of specialised enemies on the dimensionality of prey dynamics. Nature, 409, 1001-1006.

Loader, C. (1999) Local Regression and Likelihood. Springer, New York.

See Also

summary.ll.order plot.ll.order

Examples

```
data(plodia)

fit1 <- ll.order(sqrt(plodia), order=1:3, bandwidth
            = seq(0.5, 1.5, by = 0.5))

 ## Not run: plot.ll.order(fit1)

 summary.ll.order(fit1)
```

---

lpx *Utility function*

Description

hack to make ll.order work with locfit >1.5. not to be called by the user.

Usage

```
lpx(x, nn = 0, h = 0, adpen = 0, deg = 2, acri = "none",
scale = FALSE, style = "none")
```

Arguments

`x`	...
`nn`	...
`h`	...
`adpen`	...
`deg`	...
`acri`	...
`scale`	...
`style`	...

Details

not to be called by the user.

`mkx` *Utility function*

Description

A function to create matrix of lagged time series. Called by various functions.

Usage

```
mkx(x, lags)
```

Arguments

`x`	The univariate time series.
`lags`	The vector of lags.

Details

If lags is `c(1,4)`, say, then the function returns a matrix that consist of columns x(t-1), x(t-4), x(t).

Value

A matrix of lagged abundances. The last column is the current

Author(s)

Upmanu Lall

plodia *Time series of Meal Moth abundance*

Description

This is replicate 3 in Bjornstad et al. (1998).

Usage

```
data(plodia)
```

Format

A vector containing 55 values

References

Bjornstad, O. N., M. Begon, N. C. Stenseth, W. Falck, S. M. Sait, and D. J. Thompson. 1998. Population dynamics of the Indian meal moth: demographic stochasticity and delayed regulatory mechanisms. Journal of Animal Ecology 67:110-126.

plot.contingency.periodogram
Plots contingency periodograms

Description

'plot' method for class "contingency.periodogram".

Usage

```
## S3 method for class 'contingency.periodogram'
plot(x, ...)
```

Arguments

`x`	an object of class "contingency.periodogram", usually, as a result of a call to `contingency.periodogram`.
`...`	no other arguments currently allowed

Value

A contingency periodogram is plotted. The line represents the critical value based on the chi-squared test (95%).

See Also

`contingency.periodogram`

plot.lin.order *Plots linear cross-validation for time-series order*

Description

'plot' method for class "lin.order".

Usage

```
## S3 method for class 'lin.order'
plot(x, ...)
```

Arguments

x	an object of class "lin.order", usually, as a result of a call to `lin.order.cls` or `lin.order.mle`.
...	no other arguments currently allowed

Value

A xy-plot of order against cross-valiadation error is produced.

See Also

`lin.order.cls`

plot.ll.order *Plots nonparametric cross-validation for time-series order*

Description

'plot' method for class "ll.order".

Usage

```
## S3 method for class 'll.order'
plot(x, ...)
```

Arguments

x	an object of class "ll.order", usually, as a result of a call to `ll.order`.
...	no other arguments currently allowed

Details

See `ll.order` for details.

Value

A xy-plot of minimum cross-valiadation error against order is produced.

See Also

ll.order

---

plot.lomb *Plots Lomb periodograms*

Description

'plot' method for class "lomb".

Usage

```
    ## S3 method for class 'lomb'
plot(x, ...)
```

Arguments

x	an object of class "lomb", usually, as a result of a call to spec.lomb.
...	no other arguments currently allowed

Value

A Lomb periodogram is composed of a xy-plot of amplitude against frequency.

See Also

spec.lomb

---

plot.ppll *Ploting function for prediction profile objects*

Description

'plot' method for class "ppll".

Usage

```
    ## S3 method for class 'ppll'
plot(x, ...)
```

Arguments

`x`	an object of class "ppll", usually, as a result of a call to `prediction.profile.ll`.
`...`	no other arguments currently allowed

Details

See `prediction.profile.ll` for details.

Value

A xy-plot of one minus the cross-valiadation error (i.e. the prediction accuracy against prediction time step.

See Also

`prediction.profile.ll`

`plot.specar.ci` *Plots ar-spectra with CI's*

Description

'plot' method for class "specar.ci".

Usage

```
    ## S3 method for class 'specar.ci'
plot(x, period = TRUE, ...)
```

Arguments

`x`	an object of class "specar.ci", usually, as a result of a call to `specar.ci`.
`period`	if TRUE x-axis is period, if FALSE frequency.
`...`	no other arguments currently allowed

Value

A xy-plot of amplitude against period (or frequency).

See Also

`specar.ci`

portman.Q *The Ljung-Box test for whiteness in a time series.*

Description

portman.Q uses the cummulative ACF to test for whiteness of a time series.

Usage

```
portman.Q(x, K)
```

Arguments

x	A time series (vector without missing values).
K	the maximum lag of the ACF to be used in the test.

Details

This is the Ljung-Box version of the the Portemanteau test for whiteness (Tong 1990). It may in particular be usefull to test for whiteness in the residuals from time series models.

Value

A vector is returned consisting of the asymtpotic chi-square value, the associated d.f. and asymptotic p.val for the test of whiteness.

Author(s)

Ottar N. Bjornstad <onb1@psu.edu>

References

Tong, H. (1990) Non-linear time series : a dynamical system approach. Clarendon Press, Oxford.

Examples

```
data(plodia)

portman.Q(sqrt(plodia), K = 10)

fit <- ar(sqrt(plodia))
portman.Q(na.omit(fit$resid), K = 10)
```

predict.ll.order — *Predicted values from ll.order.*

Description

Calculates the leave-one-out predicted values for the optimal ll.order object

Usage

```
## S3 method for class 'll.order'
predict(object, ...)
```

Arguments

`object`	an object of class "ll.order", usually, as a result of a call to `ll.order`.
`...`	no other arguments currently allowed

Details

See `ll.order` for details.

Value

A data frame with observed and predicted values for the optimal ll-model is returned.

See Also

`ll.order`

prediction.profile.ll — *Nonlinear forecasting at verying lags using local polynomial regression.*

Description

A wrapper function around `ll.order` to calculate prediction profiles (a la Sugihara \& May 1990 and Yao \& Tong 1994). The method uses leave-one-out cross-validation of the local regression (with CV optimized bandwidth) against lagged-abundances at various lags.

Usage

```
prediction.profile.ll(x, step = 1:10, order = 1:5, deg = 2,
bandwidth = c(seq(0.3, 1.5, by = 0.1), 2:10))
```

Arguments

`x`	A time series without missing values.
`step`	The vector of time steps for predicition.
`order`	The candidate orders. The default is 1:5.
`deg`	The degree of the local polynomial.
`bandwidth`	The candidate bandwidths to be considered.

Details

see `ll.order` for details.

Value

An object of class "ppll" consisting of a list with the following components:

`step`	the prediction steps considered.
`CV`	the cross-validation error.
`order`	the optimal order for each step.
`bandwidth`	the otpimal bandwidth for each step.
`df`	the degrees of freedom for each step.

Author(s)

Ottar N. Bjornstad <onb1@psu.edu>

References

Sugihara, G., and May, R.M. (1990) Nonlinear forecasting as a way of distinguishing chaos from measurement error in time series. Nature 344, 734-741

Yao, Q. and Tong, H. (1994) Quantifying the influence of initial values on non-linear prediction. Journal of Royal Statistical Society B, 56, 701-725.

Fan, J., Yao, Q., and Tong, H. (1996) Estimation of conditional densities and sensitivity measures in nonlinear dynamical systems. Biometrika, 83, 189-206.

See Also

`ll.order`

Examples

```
data(plodia)

  fit1 <- prediction.profile.ll(sqrt(plodia), step=1:3, order=1:3,
       bandwidth = seq(0.5, 1.5, by = 0.5))

 ## Not run: plot.ppll(fit1)
```

print.ll.order — *Prints nonparametric cross-validation for time-series order*

Description

'print' method for class "ll.order".

Usage

```
## S3 method for class 'll.order'
print(x, verbose = FALSE, ...)
```

Arguments

`x`	an object of class "ll.order", usually, as a result of a call to `ll.order`.
`verbose`	if TRUE provides a raw-printing of the object.
`...`	no other arguments currently allowed

Details

See `ll.order` for details.

Value

A matrix summarizing the minimum cross-validation error (cv.min) and the associated Gaussian-kernel bandwidth (bandwidth.opt) and model degrees-of-freedom for each order considered.

See Also

`ll.order`

spec.lomb — *The funcion to estimate the Lomb periodogram for unevenly sampled data*

Description

The function to estimate the Lomb periodogram for a spectral analysis of unevenly sampled data.

Usage

```
spec.lomb(y, x, freq = NULL)
```

Arguments

- `y` — vector of length n representing the unevenly sampled time series.
- `x` — the a vector (of length n) representing the times of observation.
- `freq` — the frequencies at which the periodogram is to be calculated. If NULL the canonical frequencies (the Fourier frequencies) are used.

Details

This is the Lomb periodogram to test for periodicity in time series of unevenly sampled data.

Missing values should be deleted in both x and y before execution.

Value

An object of class "lomb" is returned consisting of the following components:

- `freq` — the frequencies as supplied.
- `spec` — the estimated amplitudes at the different frequencies.
- `f.max` — the frequency of maximum amplitude.
- `per.max` — the corresponding period of maximum amplitude.
- `p` — the level of significance associated with the max period.

Author(s)

Ottar N. Bjornstad <onb1@psu.edu>

References

Lomb, N.R. (1976) Least-squares frequency-analysis of unequally spaced data. Astrophysics and Space Science 39, 447-462.

See Also

`plot.lomb` `summary.lomb`

Examples

```
data(plodia)

 y <- sqrt(plodia)
 x <- 1:length(y)

 #make some missing values
 y[10:19] <- NA; x[10:19] <- NA
 #omit NAs
 y <- na.omit(y); x <- na.omit(x)

 #the lomb p'gram
 fit <- spec.lomb(y, x)
```

```
summary.lomb(fit)
## Not run: plot.lomb(fit)
```

---

specar.ci — *Confidence interval for the ar-spectrum and the dominant period.*

Description

A funcion to estimate a "confidence interval" for the power spectrum and in particular a confidence interval for the dominant period. The function uses resampling of the autoregressive parameters to attain the estimate.

Usage

```
specar.ci(x, order, resamp = 500, nfreq = 100, echo = TRUE)
```

Arguments

`x`	A time series without missing values.
`order`	a scalar representing the order to be considered. If `"aic"` the orderis be selected automatically using the AIC criterion.
`resamp`	the number of resamples of the ar-coefficients from the var-covar matrix.
`nfreq`	the number of points at which to save the value for the power spectrum (and confidence envelope).
`echo`	If `TRUE`, a counter for each nrun shows the progress.

Details

A "confidence interval" for the periodogram is obtained by resampling the ar-coefficients using the variance-covariance matrix from the ar.mle object.

If a zero'th order process is chosen by using the AIC criterion, a first order process will be used.

If the dynamics is highly nonlinear, the parametric estimate of the power spectrum may be inappropriate.

Value

An object of class "specar.ci" is returned consisting of the following components:

`order`	the ar-order.
`spectrum$freq`	the spectral frequencies.
`spectrum$spec`	the estimated power-spectrum of the data.
`resamp$spectrum`	gives the quantile summary for the resampling distribution of the spectral powers.
`resamp$maxfreq`	the full vector of output for the resampled max.frequencies.

Author(s)

Ottar N. Bjornstad <onb1@psu.edu>

See Also

plot.specar.ci summary.specar.ci

Examples

```
data(plodia)


 fit <- specar.ci(sqrt(plodia), order=3, resamp=10)

 ## Not run: plot.specar.ci(fit, period=FALSE)

 summary.specar.ci(fit)
```

---

summary.lin.order *Summarize linear cross-validation for time-series order*

Description

'summary' method for class "lin.order".

Usage

```
## S3 method for class 'lin.order'
summary(object, ...)
```

Arguments

object	an object of class "lin.order", usually, as a result of a call to `lin.order.cls` or `lin.order.mle`.
...	no other arguments currently allowed

Value

A slightly prettyfied version of the object is printed.

See Also

lin.order.cls

summary.ll.order *Summarize nonparametric cross-validation for time-series order*

Description

'summary' method for class "ll.order".

Usage

```
    ## S3 method for class 'll.order'
summary(object, GCV = FALSE, ...)
```

Arguments

`object`	an object of class "ll.order", usually, as a result of a call to `ll.order`.
`GCV`	if TRUE (or if cross-valdiation was not done), uses GCV values.
`...`	no other arguments currently allowed

Details

See `ll.order` for details.

Value

A matrix summarizing the minimum cross-validation error (cv.min) and the associated Gaussian-kernel bandwidth (bandwidth.opt) and model degrees-of-freedom for each order considered.

See Also

`ll.order`

summary.lomb *Summarizes Lomb periodograms*

Description

'summary' method for class "lomb".

Usage

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

Arguments

`object`	an object of class "lomb", usually, as a result of a call to `spec.lomb`.
`...`	no other arguments currently allowed

Value

A list summarizing the analysis is printed:

`period`	the dominant period.
`p.val`	the p.value.

See Also

`spec.lomb`

`summary.specar.ci` *Summarizes ar-spectra with CI's*

Description

'summary' method for class "specar.ci".

Usage

```
    ## S3 method for class 'specar.ci'
summary(object, period=TRUE, ...)
```

Arguments

`object`	an object of class "specar.ci", usually, as a result of a call to `specar.ci`.
`period`	If TRUE the summary is given in terms of the period, if false it is in terms of the frequency
`...`	no other arguments currently allowed

Value

A list summarizing the analysis is printed:

`period`	the dominant period.
`p.val`	the p.value.

See Also

`specar.ci`

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