Package ‘timsac’

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Title Time Series Analysis and Control Package

Author The Institute of Statistical Mathematics

Maintainer Masami Saga <msaga@mtb.biglobe.ne.jp>

Depends R (>= 3.0.0)

Imports graphics, grDevices, stats

Description Functions for statistical analysis, prediction and control of time series based mainly on Akaike and Nakagawa (1988) <ISBN 978-90-277-2786-2>.

MailingList Please send bug reports to ismrp@jasp.ism.ac.jp.

NeedsCompilation yes

Archs i386, x64

R topics documented:

`timsac-package` *Time Series Analysis and Control Program Package*

Description

R functions for statistical analysis and control of time series.

Details

This package provides functions for statistical analysis, prediction and control of time series. The original TIMSAC (TIMe Series Analysis and Control) or TIMSAC-72 was published in Akaike and Nakagawa (1972). After that, TIMSAC-74, TIMSAC-78 and TIMSAC-84 were published as the TIMSAC series in Computer Science Monograph.

For overview of models and information criteria for model selection, see `../doc/timsac-guide_e.pdf` or `../doc/timsac-guide_j.pdf` (in Japanese).

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.5, Timsac74, A Time Series Analysis and Control Program Package (1).* The Institute of Statistical Mathematics.

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.6, Timsac74, A Time Series Analysis and Control Program Package (2).* The Institute of Statistical Mathematics.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

H.Akaike, T.Ozaki, M.Ishiguro, Y.Ogata, G.Kitagawa, Y-H.Tamura, E.Arahata, K.Katsura and Y.Tamura (1985) *Computer Science Monograph, No.22, Timsac84 Part 1.* The Institute of Statistical Mathematics.

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

`Airpollution` *Airpollution Data*

Description

An airpollution data for testing `perars`.

Usage

```
data(Airpollution)
```

Format

A time series of 372 observations.

Source

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

`Amerikamaru` *Amerikamaru Data*

Description

A multivariate non-stationary data for testing `blomar`.

Usage

```
data(Amerikamaru)
```

Format

A 2-dimensional array with 896 observations on 2 variables.

[, 1]	rudder
[, 2]	yawing

Source

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

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armafit *ARMA Model Fitting*

Description

Fit an ARMA model with specified order by using DAVIDON's algorithm.

Usage

```
armafit(y, model.order)
```

Arguments

y	a univariate time series.
model.order	a numerical vector of the form c(ar, ma) which gives the order to be fitted successively.

Details

The maximum likelihood estimates of the coefficients of a scalar ARMA model

$$y(t) - a(1)y(t-1) - ... - a(p)y(t-p) = u(t) - b(1)u(t-1) - ... - b(q)u(t-q)$$

of a time series $y(t)$ are obtained by using DAVIDON's algorithm. Pure autoregression is not allowed.

Value

arcoef	maximum likelihood estimates of AR coefficients.
macoef	maximum likelihood estimates of MA coefficients.
arstd	standard deviation (AR).
mastd	standard deviation (MA).
v	innovation variance.
aic	AIC.
grad	final gradient.

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.5, Timsac74, A Time Series Analysis and Control Program Package (1).* The Institute of Statistical Mathematics.

Examples

```
# "arima.sim" is a function in "stats".
# Note that the sign of MA coefficient is opposite from that in "timsac".
y <- arima.sim(list(order=c(2,0,1), ar=c(0.64,-0.8), ma=-0.5), n = 1000)
z <- armafit(y, model.order = c(2,1))
z$arcoef
z$macoef
```

auspec *Power Spectrum*

Description

Compute power spectrum estimates for two trigonometric windows of Blackman-Tukey type by Goertzel method.

Usage

```
auspec(y, lag = NULL, window = "Akaike", log = FALSE, plot = TRUE)
```

Arguments

`y`	a univariate time series.
`lag`	maximum lag. Default is $2\sqrt{n}$, where n is the length of time series `y`.
`window`	character string giving the definition of smoothing window. Allowed strings are "Akaike" (default) or "Hanning".
`log`	logical. If `TRUE`, the spectrum `spec` is plotted as log(`spec`).
`plot`	logical. If `TRUE` (default), the spectrum `spec` is plotted.

Details

Hanning Window :	a1(0)=0.5,	a1(1)=a1(-1)=0.25,	a1(2)=a1(-2)=0
Akaike Window :	a2(0)=0.625,	a2(1)=a2(-1)=0.25,	a2(2)=a2(-2)=-0.0625

Value

`spec`	spectrum smoothing by '`window`'
`stat`	test statistics.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
y <- arima.sim(list(order=c(2,0,0), ar=c(0.64,-0.8)), n = 200)
auspec(y, log = TRUE)
```

autcor — *Autocorrelation*

Description

Estimate autocovariances and autocorrelations.

Usage

```
autcor(y, lag = NULL, plot = TRUE, lag_axis = TRUE)
```

Arguments

y	a univariate time series.
lag	maximum lag. Default is $2\sqrt{n}$, where n is the length of the time series y.
plot	logical. If TRUE (default), autocorrelations are plotted.
lag_axis	logical. If TRUE (default) with plot = TRUE, x-axis is drawn.

Value

acov	autocovariances.
acor	autocorrelations (normalized covariances).
mean	mean of y.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
# Example 1 for the normal distribution
y <- rnorm(200)
autcor(y, lag_axis = FALSE)

# Example 2 for the ARIMA model
y <- arima.sim(list(order=c(2,0,0), ar=c(0.64,-0.8)), n = 200)
autcor(y, lag = 20)
```

`autoarmafit` *Automatic ARMA Model Fitting*

Description

Provide an automatic ARMA model fitting procedure. Models with various orders are fitted and the best choice is determined with the aid of the statistics AIC.

Usage

```
autoarmafit(y, max.order = NULL)
```

Arguments

`y`	a univariate time series.
`max.order`	upper limit of AR order and MA order. Default is $2\sqrt{n}$, where n is the length of the time series `y`.

Details

The maximum likelihood estimates of the coefficients of a scalar ARMA model

$$y(t) - a(1)y(t-1) - ... - a(p)y(t-p) = u(t) - b(1)u(t-1) - ... - b(q)u(t-q)$$

of a time series $y(t)$ are obtained by using DAVIDON's variance algorithm. Where p is AR order, q is MA order and $u(t)$ is a zero mean white noise. Pure autoregression is not allowed.

Value

`best.model`	the best choice of ARMA coefficients.
`model`	a list with components `arcoef` (Maximum likelihood estimates of AR coefficients), `macoef` (Maximum likelihood estimates of MA coefficients), `arstd` (AR standard deviation), `mastd` (MA standard deviation), `v` (Innovation variance), `aic` (AIC $= n\log(det(v)) + 2(p+q)$) and `grad` (Final gradient) in AIC increasing order.

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.5, Timsac74, A Time Series Analysis and Control Program Package (1).* The Institute of Statistical Mathematics.

Examples

```
# "arima.sim" is a function in "stats".
# Note that the sign of MA coefficient is opposite from that in "timsac".
y <- arima.sim(list(order=c(2,0,1),ar=c(0.64,-0.8),ma=-0.5), n = 1000)
autoarmafit(y)
```

baysea *Bayesian Seasonal Adjustment Procedure*

Description

Decompose a nonstationary time series into several possible components.

Usage

```
baysea(y, period = 12, span = 4, shift = 1, forecast = 0, trend.order = 2,
       seasonal.order = 1, year = 0, month = 1, out = 0, rigid = 1,
       zersum = 1, delta = 7, alpha = 0.01, beta = 0.01, gamma = 0.1,
       spec = TRUE, plot = TRUE, separate.graphics = FALSE)
```

Arguments

`y`	a univariate time series.
`period`	number of seasonals within a period.
`span`	number of periods to be processed at one time.
`shift`	number of periods to be shifted to define the new span of data.
`forecast`	length of forecast at the end of data.
`trend.order`	order of differencing of trend.
`seasonal.order`	order of differencing of seasonal. `seasonal.order` is smaller than or equal to `span`.
`year`	trading-day adjustment option. = 0 : without trading day adjustment > 0 : with trading day adjustment (the series is supposed to start at this `year`)
`month`	number of the month in which the series starts. If `year`=0 this parameter is ignored.
`out`	outlier correction option. 0 : without outlier detection 1 : with outlier detection by marginal probability 2 : with outlier detection by model selection
`rigid`	controls the rigidity of the seasonal component. more rigid seasonal with larger than rigid.
`zersum`	controls the sum of the seasonals within a period.
`delta`	controls the leap year effect.
`alpha`	controls prior variance of initial trend.
`beta`	controls prior variance of initial seasonal.
`gamma`	controls prior variance of initial sum of seasonal.
`spec`	logical. If `TRUE` (default), estimate spectra of irregular and differenced adjusted.

plot — logical. If TRUE (default), plot trend, adjust, smoothed, season and irregular.

separate.graphics — logical. If TRUE, a graphic device is opened for each graphics display.

Details

This function realized a decomposition of time series y into the form

$$y(t) = T(t) + S(t) + I(t) + TDC(t) + OCF(t)$$

where $T(t)$ is trend component, $S(t)$ is seasonal component, $I(t)$ is irregular, $TDC(t)$ is trading day factor and $OCF(t)$ is outlier correction factor. For the purpose of comparison of models the criterion ABIC is defined

$$ABIC = -2\log(maximum\ likelihood\ of\ the\ model).$$

Smaller value of ABIC represents better fit.

Value

outlier	outlier correction factor.
trend	trend.
season	seasonal.
tday	trading day component if year > 0.
irregular	= y - trend - season - tday - outlier.
adjust	= trend - irregular.
smoothed	= trend + season + tday.
aveABIC	averaged ABIC.
irregular.spec	a list with components acov (autocovariances), acor (normalized covariances), mean, v (innovation variance), aic (AIC), parcor (partial autocorrelation) and rspec (rational spectrum) of irregular if spec = TRUE.
adjusted.spec	a list with components acov, acor, mean, v, aic, parcor and rspec of differenced adjusted series if spec = TRUE.
differenced.trend	a list with components acov, acor, mean, v, aic and parcor of differenced trend series if spec = TRUE.
differenced.season	a list with components acov, acor, mean, v, aic and parcor of differenced seasonal series if spec = TRUE.

References

H.Akaike, T.Ozaki, M.Ishiguro, Y.Ogata, G.Kitagawa, Y-H.Tamura, E.Arahata, K.Katsura and Y.Tamura (1985) *Computer Science Monograph, No.22, Timsac84 Part 1*. The Institute of Statistical Mathematics.

Examples

```
data(LaborData)
baysea(LaborData, forecast = 12)
```

`bispec` *Bispectrum*

Description

Compute bi-spectrum using the direct Fourier transform of sample third order moments.

Usage

```
bispec(y, lag = NULL, window = "Akaike", log = FALSE, plot = TRUE)
```

Arguments

`y`	a univariate time series.
`lag`	maximum lag. Default is $2\sqrt{n}$, where n is the length of the time series `y`.
`window`	character string giving the definition of smoothing window. Allowed strings are "Akaike" (default) or "Hanning".
`log`	logical. If `TRUE`, the spectrum `pspec` is plotted as $log($`pspec`$)$.
`plot`	logical. If `TRUE` (default), the spectrum `pspec` is plotted.

Details

Hanning Window :	a1(0)=0.5,	a1(1)=a1(-1)=0.25,	a1(2)=a1(-2)=0
Akaike Window :	a2(0)=0.625,	a2(1)=a2(-1)=0.25,	a2(2)=a2(-2)=-0.0625

Value

`pspec`	power spectrum smoothed by '`window`'.
`sig`	significance.
`cohe`	coherence.
`breal`	real part of bispectrum.
`bimag`	imaginary part of bispectrum.
`exval`	approximate expected value of coherence under Gaussian assumption.

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.6, Timsac74, A Time Series Analysis and Control Program Package (2).* The Institute of Statistical Mathematics.

Examples

```
data(bispecData)
bispec(bispecData, lag = 30)
```

bispecData — *Univariate Test Data*

Description

A univariate data for testing bispec and thirmo.

Usage

```
data(bispecData)
```

Format

A time series of 1500 observations.

Source

H.Akaike, E.Arahata and T.Ozaki (1976) *Computer Science Monograph, No.6, Timsac74 A Time Series Analysis and Control Program Package (2).* The Institute of Statistical Mathematics.

blocar — *Bayesian Method of Locally Stationary AR Model Fitting; Scalar Case*

Description

Locally fit autoregressive models to non-stationary time series by a Bayesian procedure.

Usage

```
blocar(y, max.order = NULL, span, plot = TRUE)
```

Arguments

y	a univariate time series.
max.order	upper limit of the order of AR model. Default is $2\sqrt{n}$, where n is the length of the time series y.
span	length of basic local span.
plot	logical. If TRUE (default), spectrums pspec are plotted.

Details

The basic AR model of scalar time series $y(t)(t = 1, \ldots, n)$ is given by

$$y(t) = a(1)y(t-1) + a(2)y(t-2) + \ldots + a(p)y(t-p) + u(t),$$

where p is order of the model and $u(t)$ is Gaussian white noise with mean 0 and variance v. At each stage of modeling of locally AR model, a two-step Bayesian procedure is applied

1. Averaging of the models with different orders fitted to the newly obtained data.
2. Averaging of the models fitted to the present and preceding spans.

AIC of the model fitted to the new span is defined by

$$AIC = ns \log(sd) + 2k,$$

where ns is the length of new data, sd is innovation variance and k is the equivalent number of parameters, defined as the sum of squares of the Bayesian weights. AIC of the model fitted to the preceding spans are defined by

$$AIC(j+1) = ns \log(sd(j)) + 2,$$

where $sd(j)$ is the prediction error variance by the model fitted to j periods former span.

Value

`var`	variance.
`aic`	AIC.
`bweight`	Bayesian weight.
`pacoef`	partial autocorrelation.
`arcoef`	coefficients (average by the Bayesian weights).
`v`	innovation variance.
`init`	initial point of the data fitted to the current model.
`end`	end point of the data fitted to the current model.
`pspec`	power spectrum.

References

G.Kitagawa and H.Akaike (1978) A Procedure for The Modeling of Non-Stationary Time Series. Ann. Inst. Statist. Math., 30, B, 351–363.

H.Akaike (1978) A Bayesian Extension of the Minimum AIC Procedure of Autoregressive Model Fitting. Research Memo. NO.126. The Institute of The Statistical Mathematics.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(locarData)
z <- blocar(locarData, max.order = 10, span = 300)
z$arcoef
```

`blomar` *Bayesian Method of Locally Stationary Multivariate AR Model Fitting*

Description

Locally fit multivariate autoregressive models to non-stationary time series by a Bayesian procedure.

Usage

```
blomar(y, max.order = NULL, span)
```

Arguments

`y`	A multivariate time series.
`max.order`	upper limit of the order of AR model, less than or equal to $n/2d$ where n is the length and d is the dimension of the time series `y`. Default is $min(2\sqrt{n}, n/2d)$.
`span`	length of basic local span. Let m denote `max.order`, if $n - m - 1$ is less than or equal to `span` or $n - m - 1-$`span` is less than $2md$, `span` is $n - m$.

Details

The basic AR model is given by

$$y(t) = A(1)y(t-1) + A(2)y(t-2) + \ldots + A(p)y(t-p) + u(t),$$

where p is order of the AR model and $u(t)$ is innovation variance `v`.

Value

`mean`	mean.
`var`	variance.
`bweight`	Bayesian weight.
`aic`	AIC with respect to the present data.
`arcoef`	AR coefficients. `arcoef[[m]][i,j,k]` shows the value of i-th row, j-th column, k-th order of m-th model.
`v`	innovation variance.
`eaic`	equivalent AIC of Bayesian model.
`init`	start point of the data fitted to the current model.
`end`	end point of the data fitted to the current model.

References

G.Kitagawa and H.Akaike (1978) A Procedure for the Modeling of Non-stationary Time Series. Ann. Inst. Statist. Math., 30, B, 351–363.

H.Akaike (1978) A Bayesian Extension of The Minimum AIC Procedure of Autoregressive Model Fitting. Research Memo. NO.126. The institute of Statistical Mathematics.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(Amerikamaru)
blomar(Amerikamaru, max.order = 10, span = 300)
```

`Blsallfood` *Blsallfood Data*

Description

The BLSALLFOOD data. (the Bureau of Labor Statistics, all employees in food industries, January 1967 - December 1979)

Usage

```
data(Blsallfood)
```

Format

A time series of 156 observations.

Source

H.Akaike, T.Ozaki, M.Ishiguro, Y.Ogata, G.Kitagawa, Y-H.Tamura, E.Arahata, K.Katsura and Y.Tamura (1984) *Computer Science Monographs, Timsac-84 Part 1.* The Institute of Statistical Mathematics.

`bsubst` *Bayesian Type All Subset Analysis*

Description

Produce Bayesian estimates of time series models such as pure AR models, AR models with non-linear terms, AR models with polynomial type mean value functions, etc. The goodness of fit of a model is checked by the analysis of several steps ahead prediction errors.

Usage

```
bsubst(y, mtype, lag = NULL, nreg, reg = NULL, term.lag = NULL, cstep = 5,
       plot = TRUE)
```

Arguments

`y` a univariate time series.

`mtype` model type. Allowed values are

1 :	autoregressive model,
2 :	polynomial type non-linear model (lag's read in),
3 :	polynomial type non-linear model (lag's automatically set),
4 :	AR-model with polynomial mean value function,
5,6,7 :	originally defined but omitted here.

`lag` maximum time lag. Default is $2\sqrt{n}$, where n is the length of the time series `y`.

`nreg` number of regressors.

`reg`	specification of regressor (`mtype` = 2). i-th regressor is defined by $z(n-L1(i)) \times z(n-L2(i)) \times z(n-L3(i))$, where $L1(i)$ is `reg(1,i)`, $L2(i)$ is `reg(2,i)` and $L3(i)$ is `reg(3,i)`. 0-lag term $z(n-0)$ is replaced by the constant 1.
`term.lag`	maximum time lag specify the regressors $(L1(i), L2(i), L3(i))$ (i=1,...,`nreg`) (`mtype` = 3).

term.lag[1] :	maximum time lag of linear term
term.lag[2] :	maximum time lag of squared term
term.lag[3] :	maximum time lag of quadratic crosses term
term.lag[4] :	maximum time lag of cubic term
term.lag[5] :	maximum time lag of cubic cross term.

`cstep`	prediction errors checking (up to `cstep`-steps ahead) is requested. (`mtype` = 1, 2, 3).
`plot`	logical. If `TRUE` (default), `daic`, `perr` and `peautcor` are plotted.

Details

The AR model is given by (`mtype` = 2)

$$y(t) = a(1)y(t-1) + ... + a(p)y(t-p) + u(t).$$

The non-linear model is given by (`mtype` = 2, 3)

$$y(t) = a(1)z(t,1) + a(2)z(t,2) + ... + a(p)z(t,p) + u(t).$$

Where p is AR order and $u(t)$ is Gaussian white noise with mean 0 and variance $v(p)$.

Value

`ymean`	mean of `y`.
`yvar`	variance of `y`.
`v`	innovation variance.
`aic`	AIC(m), (m=0, ...`nreg`).
`aicmin`	minimum AIC.
`daic`	AIC(m)-`aicmin` (m=0, ...`nreg`).
`order.maice`	order of minimum AIC.
`v.maice`	innovation variance attained at `order.maice`.
`arcoef.maice`	AR coefficients attained at `order.maice`.
`v.bay`	residual variance of Bayesian model.
`aic.bay`	AIC of Bayesian model.
`np.bay`	equivalent number of parameters.
`arcoef.bay`	AR coefficients of Bayesian model.
`ind.c`	index of `parcor2` in order of increasing magnitude.
`parcor2`	square of partial correlations (normalized by multiplying N).
`damp`	binomial type damper.
`bweight`	final Bayesian weights of partial correlations.

parcor.bay	partial correlations of the Bayesian model.
eicmin	minimum EIC.
esum	whole subset regression models.
npmean	mean of number of parameter.
npmean.nreg	= npmean / nreg.
perr	prediction error.
mean	mean.
var	variance.
skew	skewness.
peak	peakedness.
peautcor	autocorrelation function of 1-step ahead prediction error.
pspec	power spectrum (mtype = 1).

References

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(Canadianlynx)
Regressor <- matrix(
     c( 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 1, 2, 1, 3, 1, 2, 3,
        0, 0, 0, 0, 0, 0, 0, 0, 0,  0,  0,  0, 1, 2, 2, 3, 1, 2, 3,
        0, 0, 0, 0, 0, 0, 0, 0, 0,  0,  0,  0, 0, 0, 0, 0, 1, 2, 3 ),
     nrow = 3, ncol = 19, byrow = TRUE)
z <- bsubst(Canadianlynx, mtype = 2, lag = 12, nreg = 19, Regressor)
z$arcoef.bay
```

Canadianlynx *Time series of Canadian lynx data*

Description

A time series of Canadian lynx data for testing unimar, unibar, bsubst and exsar.

Usage

```
data(Canadianlynx)
```

Format

A time series of 114 observations.

Source

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

canarm — *Canonical Correlation Analysis of Scalar Time Series*

Description

Fit an ARMA model to stationary scalar time series through the analysis of canonical correlations between the future and past sets of observations.

Usage

```
canarm(y, lag = NULL, max.order = NULL, plot = TRUE)
```

Arguments

`y`	a univariate time series.
`lag`	maximum lag. Default is $2\sqrt{n}$, where n is the length of the time series `y`.
`max.order`	upper limit of AR order and MA order, must be less than or equal to `lag`. Default is `lag`.
`plot`	logical. If `TRUE` (default), `parcor` is plotted.

Details

The ARMA model of stationary scalar time series $y(t)(t = 1, ..., n)$ is given by

$$y(t) - a(1)y(t-1) - ... - a(p)y(t-p) = u(t) - b(1)u(t-1) - ... - b(q)u(t-q),$$

where p is AR order and q is MA order.

Value

`arinit`	AR coefficients of initial AR model fitting by the minimum AIC procedure.
`v`	innovation vector.
`aic`	AIC.
`aicmin`	minimum AIC.
`order.maice`	order of minimum AIC.
`parcor`	partial autocorrelation.
`nc`	total number of case.
`future`	number of present and future variables.
`past`	number of present and past variables.
`cweight`	future set canonical weight.
`canocoef`	canonical R.
`canocoef2`	R-squared.
`chisquar`	chi-square.
`ndf`	N.D.F.
`dic`	DIC.
`dicmin`	minimum DIC.
`order.dicmin`	order of minimum DIC.
`arcoef`	AR coefficients $a(i)(i = 1, ..., p)$.
`macoef`	MA coefficients $b(i)(i = 1, ..., q)$.

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.5, Timsac74, A Time Series Analysis and Control Program Package (1).* The Institute of Statistical Mathematics.

Examples

```
# "arima.sim" is a function in "stats".
# Note that the sign of MA coefficient is opposite from that in "timsac".
y <- arima.sim(list(order=c(2,0,1), ar=c(0.64,-0.8), ma=c(-0.5)), n = 1000)
z <- canarm(y, max.order = 30)
z$arcoef
z$macoef
```

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canoca *Canonical Correlation Analysis of Vector Time Series*

Description

Analyze canonical correlation of a d-dimensional multivariate time series.

Usage

```
canoca(y)
```

Arguments

`y`	a multivariate time series.

Details

First AR model is fitted by the minimum AIC procedure. The results are used to ortho-normalize the present and past variables. The present and future variables are tested successively to decide on the dependence of their predictors. When the last DIC (=chi-square - 2.0*N.D.F.) is negative the predictor of the variable is decided to be linearly dependent on the antecedents.

Value

`aic`	AIC.
`aicmin`	minimum AIC.
`order.maice`	MAICE AR model order.
`v`	innovation variance.
`arcoef`	autoregressive coefficients. `arcoef[i,j,k]` shows the value of i-th row, j-th column, k-th order.
`nc`	number of cases.
`future`	number of variable in the future set.
`past`	number of variables in the past set.
`cweight`	future set canonical weight.
`canocoef`	canonical R.
`canocoef2`	R-squared.

chisquar	chi-square.
ndf	N.D.F.
dic	DIC.
dicmin	minimum DIC.
order.dicmin	order of minimum DIC.
matF	the transition matrix F.
vectH	structural characteristic vector H of the canonical Markovian representation.
matG	the estimate of the input matrix G.
vectF	matrix F in vector form.

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.5, Timsac74, A Time Series Analysis and Control Program Package (1).* The Institute of Statistical Mathematics.

Examples

```
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,   0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1, 0), nrow = 3, ncol = 3, byrow= TRUE)
ar[, , 2] <- matrix(c(0,  -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow = 3, ncol = 3, byrow = TRUE)
x <- matrix(rnorm(1000*3), nrow = 1000, ncol = 3)
y <- mfilter(x, ar, "recursive")
z <- canoca(y)
z$arcoef
```

---

covgen *Covariance Generation*

Description

Produce the Fourier transform of a power gain function in the form of an autocovariance sequence.

Usage

```
covgen(lag, f, gain, plot = TRUE)
```

Arguments

lag	desired maximum lag of covariance.
f	frequency f[i] $(i = 1, ..., k)$, where k is the number of data points. By definition f[1] = 0.0 and f[k] = 0.5, f[i]'s are arranged in increasing order.
gain	power gain of the filter at the frequency f[i].
plot	logical. If TRUE (default), autocorrelations are plotted.

Value

acov	autocovariance.
acor	autocovariance normalized.

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.5, Timsac74, A Time Series Analysis and Control Program Package (1)*. The Institute of Statistical Mathematics.

Examples

```
spec <- raspec(h = 100, var = 1, arcoef = c(0.64,-0.8), plot = FALSE)
covgen(lag = 100, f = 0:100/200, gain = spec)
```

---

decomp — *Time Series Decomposition (Seasonal Adjustment) by Square-Root Filter*

Description

Decompose a nonstationary time series into several possible components by square-root filter.

Usage

```
decomp(y, trend.order = 2, ar.order = 2, seasonal.order = 1,
       period = 1, log = FALSE, trade = FALSE, diff = 1,
       miss = 0, omax = 99999.9, plot = TRUE)
```

Arguments

y	a univariate time series with or without the tsp attribute.
trend.order	trend order (0, 1, 2 or 3).
ar.order	AR order (less than 11, try 2 first).
seasonal.order	seasonal order (0, 1 or 2).
period	number of seasons in one period. If the tsp attribute of y is not NULL, frequency(y).
log	logical; if TRUE, a log scale is in use.
trade	logical; if TRUE, the model including trading day effect component is concidered, where tsp(y) is not null and frequency(y) is 4 or 12.
diff	numerical differencing (1 sided or 2 sided).
miss	missing data flag. = 0 : no consideration > 0 : values which are greater than omax are treated as missing data < 0 : values which are less than omax are treated as missing data
omax	maximum or minimum data value (if miss > 0 or miss < 0).
plot	logical. If TRUE (default), trend, seasonal, ar and trad are plotted.

Details

The Basic Model

$$y(t) = T(t) + AR(t) + S(t) + TD(t) + W(t)$$

where $T(t)$ is trend component, $AR(t)$ is AR process, $S(t)$ is seasonal component, $TD(t)$ is trading day factor and $W(t)$ is observational noise.

Component Models

- Trend component (trend.order m1)
  $m1 = 1 : T(t) = T(t-1) + V1(t)$
  $m1 = 2 : T(t) = 2T(t-1) - T(t-2) + V1(t)$
  $m1 = 3 : T(t) = 3T(t-1) - 3T(t-2) + T(t-2) + V1(t)$
- AR component (ar.order m2)
  $AR(t) = a(1)AR(t-1) + \ldots + a(m2)AR(t-m2) + V2(t)$
- Seasonal component (seasonal.order k, frequency f)
  $k = 1 : S(t) = -S(t-1) - \ldots - S(t-f+1) + V3(t)$
  $k = 2 : S(t) = -2S(t-1) - \ldots - f\,S(t-f+1) - \ldots - S(t-2f+2) + V3(t)$
- Trading day effect
  $TD(t) = b(1)TRADE(t,1) + \ldots + b(7)TRADE(t,7)$
  where $TRADE(t,i)$ is the number of i-th days of the week in t-th data and $b(1)\ +\ \ldots\ +\ b(7)\ =\ 0.$

Value

`trend`	trend component.
`seasonal`	seasonal component.
`ar`	AR process.
`trad`	trading day factor.
`noise`	observational noise.
`aic`	AIC.
`lkhd`	likelihood.
`sigma2`	sigma^2.
`tau1`	system noise variances tau2(1).
`tau2`	system noise variances tau2(2).
`tau3`	system noise variances tau2(3).
`arcoef`	vector of AR coefficients.
`tdf`	trading day factor. `tdf(i)` (i=1,7) are from Sunday to Saturday sequentially.

References

G.Kitagawa (1981) *A Nonstationary Time Series Model and Its Fitting by a Recursive Filter* Journal of Time Series Analysis, Vol.2, 103-116.

W.Gersch and G.Kitagawa (1983) *The prediction of time series with Trends and Seasonalities* Journal of Business and Economic Statistics, Vol.1, 253-264.

G.Kitagawa (1984) *A smoothness priors-state space modeling of Time Series with Trend and Seasonality* Journal of American Statistical Association, VOL.79, NO.386, 378-389.

Examples

```
data(Blsallfood)
y <- ts(Blsallfood, start=c(1967,1), frequency=12)
z <- decomp(y, trade = TRUE)
z$aic
z$lkhd
z$sigma2
z$tau1
z$tau2
z$tau3
```

---

exsar *Exact Maximum Likelihood Method of Scalar AR Model Fitting*

Description

Produce exact maximum likelihood estimates of the parameters of a scalar AR model.

Usage

```
exsar(y, max.order = NULL, plot = FALSE)
```

Arguments

y	a univariate time series.
max.order	upper limit of AR order. Default is $2\sqrt{n}$, where n is the length of the time series y.
plot	logical. If TRUE, daic is plotted.

Details

The AR model is given by

$$y(t) = a(1)y(t-1) + ... + a(p)y(t-p) + u(t)$$

where p is AR order and $u(t)$ is a zero mean white noise.

Value

mean	mean.
var	variance.
v	innovation variance.
aic	AIC.
aicmin	minimum AIC.
daic	AIC-aicmin.
order.maice	order of minimum AIC.
v.maice	MAICE innovation variance.
arcoef.maice	MAICE AR coefficients.
v.mle	maximum likelihood estimates of innovation variance.
arcoef.mle	maximum likelihood estimates of AR coefficients.

References

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(Canadianlynx)
z <- exsar(Canadianlynx, max.order = 14)
z$arcoef.maice
z$arcoef.mle
```

---

fftcor *Auto And/Or Cross Correlations via FFT*

Description

Compute auto and/or cross covariances and correlations via FFT.

Usage

```
fftcor(y, lag = NULL, isw = 4, plot = TRUE, lag_axis = TRUE)
```

Arguments

y	data of channel X and Y (data of channel Y is given for isw = 2 or 4 only).
lag	maximum lag. Default is $2\sqrt{n}$, where n is the length of the time series y.
isw	numerical flag giving the type of computation. 1 : auto-correlation of X (one-channel) 2 : auto-correlations of X and Y (two-channel) 4 : auto- and cross- correlations of X and Y (two-channel)
plot	logical. If TRUE (default), cross-correlations are plotted.
lag_axis	logical. If TRUE (default) with plot=TRUE, x-axis is drawn.

Value

acov	auto-covariance.
ccov12	cross-covariance.
ccov21	cross-covariance.
acor	auto-correlation.
ccor12	cross-correlation.
ccor21	cross-correlation.
mean	mean.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
# Example 1
x <- rnorm(200)
y <- rnorm(200)
xy <- array(c(x,y), dim = c(200,2))
fftcor(xy, lag_axis = FALSE)

# Example 2
xorg <- rnorm(1003)
x <- matrix(0, nrow = 1000, ncol = 2)
x[, 1] <- xorg[1:1000]
x[, 2] <- xorg[4:1003] + 0.5*rnorm(1000)
fftcor(x, lag = 20)
```

`fpeaut` *FPE Auto*

Description

Perform FPE(Final Prediction Error) computation for one-dimensional AR model.

Usage

```
fpeaut(y, max.order = NULL)
```

Arguments

`y`	a univariate time series.
`max.order`	upper limit of model order. Default is $2\sqrt{n}$, where n is the length of the time series `y`.

Details

The AR model is given by

$$y(t) = a(1)y(t-1) + ... + a(p)y(t-p) + u(t)$$

where p is AR order and $u(t)$ is a zero mean white noise.

Value

`ordermin`	order of minimum FPE.
`best.ar`	AR coefficients with minimum FPE.
`sigma2m`	= `sigma2(ordermin)`.
`fpemin`	minimum FPE.
`rfpemin`	minimum RFPE.
`ofpe`	OFPE.
`arcoef`	AR coefficients.
`sigma2`	σ^2.
`fpe`	FPE (Final Prediction Error).
`rfpe`	RFPE.
`parcor`	partial correlation.
`chi2`	chi-squared.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
y <- arima.sim(list(order=c(2,0,0), ar=c(0.64,-0.8)), n = 200)
fpeaut(y, max.order = 20)
```

`fpec` *AR model Fitting for Control*

Description

Perform AR model fitting for control.

Usage

```
fpec(y, max.order = NULL, control = NULL, manip = NULL)
```

Arguments

`y`	a multivariate time series.
`max.order`	upper limit of model order. Default is $2\sqrt{n}$, where n is the length of time series `y`.
`control`	controlled variables. Default is $c(1:d)$, where d is the dimension of the time series `y`.
`manip`	manipulated variables. Default number of manipulated variable is 0.

Value

`cov`	covariance matrix rearrangement.
`fpec`	FPEC (AR model fitting for control).
`rfpec`	RFPEC.
`aic`	AIC.
`ordermin`	order of minimum FPEC.
`fpecmin`	minimum FPEC.
`rfpecmin`	minimum RFPEC.
`aicmin`	minimum AIC.
`perr`	prediction error covariance matrix.
`arcoef`	a set of coefficient matrices. `arcoef[i,j,k]` shows the value of i-th row, j-th column, k-th order.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,   0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1, 0), nrow = 3, ncol = 3, byrow = TRUE)
ar[, , 2] <- matrix(c(0,   -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow = 3, ncol = 3, byrow = TRUE)
x <- matrix(rnorm(200*3), nrow = 200, ncol = 3)
y <- mfilter(x, ar, "recursive")
fpec(y, max.order = 10)
```

`LaborData` *Labor force Data*

Description

Labor force U.S. unemployed 16 years or over (1972-1978) data.

Usage

```
data(LaborData)
```

Format

A time series of 72 observations.

Source

H.Akaike, T.Ozaki, M.Ishiguro, Y.Ogata, G.Kitagawa, Y-H.Tamura, E.Arahata, K.Katsura and Y.Tamura (1985) *Computer Science Monograph, No.22, Timsac84 Part 1.* The Institute of Statistical Mathematics.

`locarData` *Non-stationary Test Data*

Description

A non-stationary data for testing `mlocar` and `blocar`.

Usage

```
data(locarData)
```

Format

A time series of 1000 observations.

Source

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

markov *Maximum Likelihood Computation of Markovian Model*

Description

Compute maximum likelihood estimates of Markovian model.

Usage

```
markov(y)
```

Arguments

y	a multivariate time series.

Details

This function is usually used with simcon.

Value

id	id[i]$= 1$ means that the i-th row of F contains free parameters.
ir	ir[i] denotes the position of the last non-zero element within the i-th row of F.
ij	ij[i] denotes the position of the i-th non-trivial row within F.
ik	ik[i] denotes the number of free parameters within the i-th non-trivial row of F.
grad	gradient vector.
matFi	initial estimate of the transition matrix F.
matF	transition matrix F.
matG	input matrix G.
davvar	DAVIDON variance.
arcoef	AR coefficient matrices. arcoef[i,j,k] shows the value of i-th row, j-th column, k-th order.
impulse	impulse response matrices.
macoef	MA coefficient matrices. macoef[i,j,k] shows the value of i-th row, j-th column, k-th order.
v	innovation variance.
aic	AIC.

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.5, Timsac74, A Time Series Analysis and Control Program Package (1).* The Institute of Statistical Mathematics.

Examples

```
x <- matrix(rnorm(1000*2), nrow = 1000, ncol = 2)
ma <- array(0, dim = c(2,2,2))
ma[, , 1] <- matrix(c( -1.0,  0.0,
                        0.0, -1.0), nrow = 2, ncol = 2, byrow = TRUE)
ma[, , 2] <- matrix(c( -0.2,  0.0,
                       -0.1, -0.3), nrow = 2, ncol = 2, byrow = TRUE)
y <- mfilter(x, ma, "convolution")
ar <- array(0, dim = c(2,2,3))
ar[, , 1] <- matrix(c( -1.0,  0.0,
                        0.0, -1.0), nrow = 2, ncol = 2, byrow = TRUE)
ar[, , 2] <- matrix(c( -0.5, -0.2,
                       -0.2, -0.5), nrow = 2, ncol = 2, byrow = TRUE)
ar[, , 3] <- matrix(c( -0.3, -0.05,
                       -0.1, -0.30), nrow = 2, ncol = 2, byrow = TRUE)
z <- mfilter(y, ar, "recursive")
markov(z)
```

---

mfilter — *Linear Filtering on a Multivariate Time Series*

Description

Applies linear filtering to a multivariate time series.

Usage

```
mfilter(x, filter, method = c("convolution","recursive"), init)
```

Arguments

`x`	a multivariate (m-dimensional, n length) time series $x[n, m]$.
`filter`	an array of filter coefficients. `filter[i,j,k]` shows the value of i-th row, j-th column, k-th order
`method`	either "convolution" or "recursive" (and can be abbreviated). If "convolution" a moving average is used: if "recursive" an autoregression is used. For convolution filters, the filter coefficients are for past value only.
`init`	specifies the initial values of the time series just prior to the start value, in reverse time order. The default is a set of zeros.

Details

This is a multivariate version of "filter" function. Missing values are allowed in 'x' but not in '`filter`' (where they would lead to missing values everywhere in the output). Note that there is an implied coefficient 1 at lag 0 in the recursive filter, which gives

$$y[i,]' = x[,i]' + f[,,1] \times y[i-1,]' + ... + f[,,p] \times y[i-p,]',$$

No check is made to see if recursive filter is invertible: the output may diverge if it is not. The convolution filter is

$$y[i,]' = f[,,1] \times x[i,]' + ... + f[,,p] \times x[i-p+1,]'.$$

Value

`mfilter` returns a time series object.

Note

'`convolve(,type="filter")`' uses the FFT for computations and so may be faster for long filters on univariate time series (and so the time alignment is unclear), nor does it handle missing values. 'filter' is faster for a filter of length 100 on a series 1000, for examples.

See Also

`convolve`, `arima.sim`

Examples

```
#AR model simulation
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,   0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1, 0), nrow = 3, ncol = 3, byrow = TRUE)
ar[, , 2] <- matrix(c(0,  -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow = 3, ncol = 3, byrow = TRUE)
x <- matrix(rnorm(100*3), nrow = 100, ncol = 3)
y <- mfilter(x, ar, "recursive")

#Back to white noise
ma <- array(0, dim = c(3,3,3))
ma[, , 1] <- diag(3)
ma[, , 2] <- -ar[, , 1]
ma[, , 3] <- -ar[, , 2]
z <- mfilter(y, ma, "convolution")
mulcor(z)

#AR-MA model simulation
x <- matrix(rnorm(1000*2), nrow = 1000, ncol = 2)
ma <- array(0, dim = c(2,2,2))
ma[, , 1] <- matrix(c( -1.0,  0.0,
                        0.0, -1.0), nrow = 2, ncol = 2, byrow = TRUE)
ma[, , 2] <- matrix(c( -0.2,  0.0,
                       -0.1, -0.3), nrow = 2, ncol = 2, byrow = TRUE)
y <- mfilter(x, ma, "convolution")

ar <- array(0, dim = c(2,2,3))
ar[, , 1] <- matrix(c( -1.0,  0.0,
                        0.0, -1.0), nrow = 2, ncol = 2, byrow = TRUE)
ar[, , 2] <- matrix(c( -0.5, -0.2,
                       -0.2, -0.5), nrow = 2, ncol = 2, byrow = TRUE)
ar[, , 3] <- matrix(c( -0.3, -0.05,
                       -0.1, -0.30), nrow = 2, ncol = 2, byrow = TRUE)
z <- mfilter(y, ar, "recursive")
```

`mlocar` *Minimum AIC Method of Locally Stationary AR Model Fitting; Scalar Case*

Description

Locally fit autoregressive models to non-stationary time series by minimum AIC procedure.

Usage

```
mlocar(y, max.order = NULL, span, const = 0, plot = TRUE)
```

Arguments

`y`	a univariate time series.
`max.order`	upper limit of the order of AR model. Default is $2\sqrt{n}$, where n is the length of the time series `y`.
`span`	length of the basic local span.
`const`	integer. `0` denotes constant vector is not included as a regressor and `1` denotes constant vector is included as the first regressor.
`plot`	logical. If `TRUE` (default), spectrums `pspec` are plotted.

Details

The data of length n are divided into k locally stationary spans,

$$| < -- n_1 -- > | < -- n_2 -- > | < -- n_3 -- > |.....| < -- n_k -- > |$$

where n_i $(i = 1, \ldots, k)$ denotes the number of basic spans, each of length span, which constitute the i-th locally stationary span. At each local span, the process is represented by a stationary autoregressive model.

Value

`mean`	mean.
`var`	variance.
`ns`	the number of local spans.
`order`	order of the current model.
`arcoef`	AR coefficients of current model.
`v`	innovation variance of the current model.
`init`	initial point of the data fitted to the current model.
`end`	end point of the data fitted to the current model.
`pspec`	power spectrum.
`npre`	data length of the preceding stationary block.
`nnew`	data length of the new block.
`order.mov`	order of the moving model.

v.mov	innovation variance of the moving model.
aic.mov	AIC of the moving model.
order.const	order of the constant model.
v.const	innovation variance of the constant model.
aic.const	AIC of the constant model.

References

G.Kitagawa and H.Akaike (1978) A Procedure for The Modeling of Non-Stationary Time Series. Ann. Inst. Statist. Math., 30, B, 351–363.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(locarData)
z <- mlocar(locarData, max.order = 10, span = 300, const = 0)
z$arcoef
```

---

mlomar — *Minimum AIC Method of Locally Stationary Multivariate AR Model Fitting*

Description

Locally fit multivariate autoregressive models to non-stationary time series by the minimum AIC procedure using the householder transformation.

Usage

```
mlomar(y, max.order = NULL, span, const = 0)
```

Arguments

y	a multivariate time series.
max.order	upper limit of the order of AR model, less than or equal to $n/2d$ where n is the length and d is the dimension of the time series y. Default is $min(2\sqrt{n}, n/2d)$.
span	length of basic local span. Let m denote max.order, if $n - m - 1$ is less than or equal to span or $n - m - 1-$span is less than $2md+$const, span is $n - m$.
const	integer. '0' denotes constant vector is not included as a regressor and '1' denotes constant vector is included as the first regressor.

Details

The data of length n are divided into k locally stationary spans,

$$| < - - n_1 - - > | < - - n_2 - - > | < - - n_3 - - > |.....| < - - n_k - - > |$$

where n_i $(i = 1, \ldots, k)$ denoted the number of basic spans, each of length span, which constitute the i-th locally stationary span. At each local span, the process is represented by a stationary autoregressive model.

Value

mean	mean.
var	variance.
ns	the number of local spans.
order	order of the current model.
aic	AIC of the current model.
arcoef	AR coefficient matrices of the current model. arcoef[[m]][i,j,k] shows the value of i-th row, j-th column, k-th order of m-th model.
v	innovation variance of the current model.
init	initial point of the data fitted to the current model.
end	end point of the data fitted to the current model.
npre	data length of the preceding stationary block.
nnew	data length of the new block.
order.mov	order of the moving model.
aic.mov	AIC of the moving model.
order.const	order of the constant model.
aic.const	AIC of the constant model.

References

G.Kitagawa and H.Akaike (1978) A Procedure for The Modeling of Non-Stationary Time Series. Ann. Inst. Statist. Math., 30, B, 351–363.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(Amerikamaru)
mlomar(Amerikamaru, max.order = 10, span = 300, const = 0)
```

---

mulbar *Multivariate Bayesian Method of AR Model Fitting*

Description

Determine multivariate autoregressive models by a Bayesian procedure. The basic least squares estimates of the parameters are obtained by the householder transformation.

Usage

```
mulbar(y, max.order = NULL, plot = FALSE)
```

Arguments

y	a multivariate time series.
max.order	upper limit of the order of AR model, less than or equal to $n/2d$ where n is the length and d is the dimension of the time series y. Default is $min(2\sqrt{n}, n/2d)$.
plot	logical. If TRUE, daic is plotted.

Details

The statistic AIC is defined by

$$AIC = n\log(det(v)) + 2k,$$

where n is the number of data, v is the estimate of innovation variance matrix, det is the determinant and k is the number of free parameters.

Bayesian weight of the m-th order model is defined by

$$W(n) = const \times \frac{C(m)}{m+1},$$

where $const$ is the normalizing constant and $C(m) = \exp(-0.5AIC(m))$. The Bayesian estimates of partial autoregression coefficient matrices of forward and backward models are obtained by $(m = 1,\ldots,lag)$

$$G(m) = G(m)D(m),$$
$$H(m) = H(m)D(m),$$

where the original $G(m)$ and $H(m)$ are the (conditional) maximum likelihood estimates of the highest order coefficient matrices of forward and backward AR models of order m and $D(m)$ is defined by

$$D(m) = W(m) + \ldots + W(lag).$$

The equivalent number of parameters for the Bayesian model is defined by

$$ek = \{D(1)^2 + \ldots + D(lag)^2\}id + \frac{id(id+1)}{2}$$

where id denotes dimension of the process.

Value

`mean`	mean.
`var`	variance.
`v`	innovation variance.
`aic`	AIC.
`aicmin`	minimum AIC.
`daic`	AIC-`aicmin`.
`order.maice`	order of minimum AIC.
`v.maice`	MAICE innovation variance.
`bweight`	Bayesian weights.
`integra.bweight`	integrated Bayesian Weights.
`arcoef.for`	AR coefficients (forward model). `arcoef.for[i,j,k]` shows the value of i-th row, j-th column, k-th order.
`arcoef.back`	AR coefficients (backward model). `arcoef.back[i,j,k]` shows the value of i-th row, j-th column, k-th order.
`pacoef.for`	partial autoregression coefficients (forward model).
`pacoef.back`	partial autoregression coefficients (backward model).
`v.bay`	innovation variance of the Bayesian model.
`aic.bay`	equivalent AIC of the Bayesian (forward) model.

References

H.Akaike (1978) A Bayesian Extension of The Minimum AIC Procedure of Autoregressive Model Fitting. Research Memo. NO.126, The Institute of Statistical Mathematics.

G.Kitagawa and H.Akaike (1978) A Procedure for The Modeling of Non-stationary Time Series. Ann. Inst. Statist. Math., 30, B, 351–363.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(Powerplant)
z <- mulbar(Powerplant, max.order = 10)
z$pacoef.for
z$pacoef.back
```

---

mulcor *Multiple Correlation*

Description

Estimate multiple correlation.

Usage

```
mulcor(y, lag = NULL, plot = TRUE, lag_axis = TRUE)
```

Arguments

y	a multivariate time series.
lag	maximum lag. Default is $2\sqrt{n}$, where n is the length of the time series y.
plot	logical. If TRUE (default), correlations cor are plotted.
lag_axis	logical. If TRUE (default) with plot=TRUE, x-axis is drawn.

Value

cov	covariances.
cor	correlations (normalized covariances).
mean	mean.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
# Example 1
y <- rnorm(1000)
dim(y) <- c(500,2)
mulcor(y, lag_axis = FALSE)

# Example 2
xorg <- rnorm(1003)
x <- matrix(0, nrow = 1000, ncol = 2)
x[, 1] <- xorg[1:1000]
x[, 2] <- xorg[4:1003] + 0.5*rnorm(1000)
mulcor(x, lag = 20)
```

---

mulfrf — *Frequency Response Function (Multiple Channel)*

Description

Compute multiple frequency response function, gain, phase, multiple coherency, partial coherency and relative error statistics.

Usage

```
mulfrf(y, lag = NULL, iovar = NULL)
```

Arguments

`y`	a multivariate time series.
`lag`	maximum lag. Default is $2\sqrt{n}$, where n is the number of rows in `y`.
`iovar`	input variables `iovar[i]` $(i = 1, k)$ and output variable `iovar[k+1]` $(1 \leq k \leq d)$, where d is the number of columns in `y`. Default is $c(1 : d)$.

Value

`cospec`	spectrum (complex).
`freqr`	frequency response function : real part.
`freqi`	frequency response function : imaginary part.
`gain`	gain.
`phase`	phase.
`pcoh`	partial coherency.
`errstat`	relative error statistics.
`mcoh`	multiple coherency.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,   0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1, 0), nrow = 3, ncol = 3, byrow = TRUE)
ar[, , 2] <- matrix(c(0,  -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow = 3, ncol = 3, byrow = TRUE)
x <- matrix(rnorm(200*3), nrow = 200, ncol = 3)
y <- mfilter(x, ar, "recursive")
mulfrf(y, lag = 20)
```

---

mulmar *Multivariate Case of Minimum AIC Method of AR Model Fitting*

Description

Fit a multivariate autoregressive model by the minimum AIC procedure. Only the possibilities of zero coefficients at the beginning and end of the model are considered. The least squares estimates of the parameters are obtained by the householder transformation.

Usage

```
mulmar(y, max.order = NULL, plot = FALSE)
```

Arguments

`y`	a multivariate time series.
`max.order`	upper limit of the order of AR model, less than or equal to $n/2d$ where n is the length and d is the dimension of the time series `y`. Default is $min(2\sqrt{n}, n/2d)$.
`plot`	logical. If `TRUE`, `daic[[1]]`, ... ,`daic[[d]]` are plotted.

Details

Multivariate autoregressive model is defined by

$$y(t) = A(1)y(t-1) + A(2)y(t-2) + \ldots + A(p)y(t-p) + u(t),$$

where p is order of the model and $u(t)$ is Gaussian white noise with mean 0 and variance matrix `matv`. AIC is defined by

$$AIC = n \log(det(v)) + 2k,$$

where n is the number of data, v is the estimate of innovation variance matrix, det is the determinant and k is the number of free parameters.

Value

`mean`	mean.
`var`	variance.
`v`	innovation variance.
`aic`	AIC.

`aicmin`	minimum AIC.
`daic`	AIC-aicmin.
`order.maice`	order of minimum AIC.
`v.maice`	MAICE innovation variance.
`np`	number of parameters.
`jnd`	specification of i-th regressor.
`subregcoef`	subset regression coefficients.
`rvar`	residual variance.
`aicf`	final estimate of AIC ($= n\log$(`rvar`)+2`np`).
`respns`	instantaneous response.
`matv`	innovation variance matrix.
`morder`	order of the MAICE model.
`arcoef`	AR coefficients. `arcoef[i,j,k]` shows the value of i-th row, j-th column, $k-$th order.
`aicsum`	the sum of aicf.

References

G.Kitagawa and H.Akaike (1978) A Procedure for The Modeling of Non-stationary Time Series. Ann. Inst. Statist. Math., 30, B, 351–363.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
# Example 1
data(Powerplant)
z <- mulmar(Powerplant, max.order = 10)
z$arcoef

# Example 2
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,   0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1, 0), nrow = 3, ncol = 3, byrow = TRUE)
ar[, , 2] <- matrix(c(0,  -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow = 3, ncol = 3,byrow = TRUE)
x <- matrix(rnorm(200*3), nrow = 200, ncol = 3)
y <- mfilter(x, ar, "recursive")
z <- mulmar(y, max.order = 10)
z$arcoef
```

mulnos *Relative Power Contribution*

Description

Compute relative power contributions in differential and integrated form, assuming the orthogonality between noise sources.

Usage

```
mulnos(y, max.order = NULL, control = NULL, manip = NULL, h)
```

Arguments

y	a multivariate time series.
max.order	upper limit of model order. Default is $2\sqrt{n}$, where n is the length of time series y.
control	controlled variables. Default is $c(1:d)$, where d is the dimension of the time series y.
manip	manipulated variables. Default number of manipulated variable is '0'.
h	specify frequencies $i/2$h ($i = 0,\ldots,$h).

Value

nperr	a normalized prediction error covariance matrix.
diffr	differential relative power contribution.
integr	integrated relative power contribution.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,   0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1, 0), nrow = 3, ncol = 3, byrow = TRUE)
ar[, , 2] <- matrix(c(0,  -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow = 3, ncol = 3, byrow = TRUE)
x <- matrix(rnorm(200*3), nrow = 200, ncol = 3)
y <- mfilter(x, ar, "recursive")
mulnos(y, max.order = 10, h = 20)
```

`mulrsp` *Multiple Rational Spectrum*

Description

Compute rational spectrum for d-dimensional ARMA process.

Usage

```
mulrsp(h, d, cov, ar = NULL, ma = NULL, log = FALSE, plot = TRUE,
       plot.scale = FALSE)
```

Arguments

`h`	specify frequencies $i/2$h ($i = 0, 1, ...,$h).
`d`	dimension of the observation vector.
`cov`	covariance matrix.
`ar`	coefficient matrix of autoregressive model. `ar[i,j,k]` shows the value of i-th row, j-th column, k-th order.
`ma`	coefficient matrix of moving average model. `ma[i,j,k]` shows the value of i-th row, j-th column, k-th order.
`log`	logical. If `TRUE`, rational spectrums `rspec` are plotted as $log($`rspec`$)$.
`plot`	logical. If `TRUE`, rational spectrums `rspec` are plotted.
`plot.scale`	logical. IF `TRUE`, the common range of the y-axis is used.

Details

ARMA process :

$$y(t) - A(1)y(t-1) - ... - A(p)y(t-p) = u(t) - B(1)u(t-1) - ... - B(q)u(t-q)$$

where $u(t)$ is a white noise with zero mean vector and covariance matrix `cov`.

Value

`rspec`	rational spectrum.
`scoh`	simple coherence.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
# Example 1 for the normal distribution
xorg <- rnorm(1003)
x <- matrix(0, nrow = 1000, ncol = 2)
x[, 1] <- xorg[1:1000]
x[, 2] <- xorg[4:1003] + 0.5*rnorm(1000)
aaa <- ar(x)
mulrsp(h = 20, d = 2, cov = aaa$var.pred, ar = aaa$ar, plot = TRUE,
       plot.scale = TRUE)

# Example 2 for the AR model
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,   0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1, 0), nrow = 3, ncol = 3, byrow = TRUE)
ar[, , 2] <- matrix(c(0,  -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow = 3, ncol = 3, byrow = TRUE)
x <- matrix(rnorm(200*3), nrow = 200, ncol = 3)
y <- mfilter(x, ar, "recursive")
z <- fpec(y, max.order = 10)
mulrsp(h = 20, d = 3, cov = z$perr, ar = z$arcoef)
```

---

mulspe *Multiple Spectrum*

Description

Compute multiple spectrum estimates using Akaike window or Hanning window.

Usage

```
mulspe(y, lag = NULL, window = "Akaike", plot = TRUE, plot.scale = FALSE)
```

Arguments

`y`	a multivariate time series with d variables and n observations.
`lag`	maximum lag. Default is $2\sqrt{n}$, where n is the number of observations.
`window`	character string giving the definition of smoothing window. Allowed strings are "Akaike" (default) or "Hanning".
`plot`	logical. If TRUE (default) spectrums are plotted as (d, d) matrix.

Diagonal parts :	Auto spectrums for each series.
Lower triangular parts :	Amplitude spectrums.
Upper triangular part :	Phase spectrums.

`plot.scale`	logical. IF `TRUE`, the common range of the y-axis is used.

Details

Hanning Window : a1(0)=0.5, a1(1)=a1(-1)=0.25, a1(2)=a1(-2)=0

Akaike Window : a2(0)=0.625, a2(1)=a2(-1)=0.25, a2(2)=a2(-2)=-0.0625

Value

`spec` spectrum smoothing by 'window'.

Lower triangular parts :	Real parts
Upper triangular parts :	Imaginary parts

`stat` test statistics.

`coh` simple coherence by 'window'.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
sgnl <- rnorm(1003)
x <- matrix(0, nrow = 1000, ncol = 2)
x[, 1] <- sgnl[4:1003]
# x[i,2] = 0.9*x[i-3,1] + 0.2*N(0,1)
x[, 2] <- 0.9*sgnl[1:1000] + 0.2*rnorm(1000)
mulspe(x, lag = 100, window = "Hanning", plot.scale = TRUE)
```

`nonst` *Non-stationary Power Spectrum Analysis*

Description

Locally fit autoregressive models to non-stationary time series by AIC criterion.

Usage

```
nonst(y, span, max.order = NULL, plot = TRUE)
```

Arguments

`y` a univariate time series.

`span` length of the basic local span.

`max.order` highest order of AR model. Default is $2\sqrt{n}$, where n is the length of the time series `y`.

`plot` logical. If `TRUE` (the default), spectrums are plotted.

Details

The basic AR model is given by

$$y(t) = A(1)y(t-1) + A(2)y(t-2) + ... + A(p)y(t-p) + u(t),$$

where p is order of the AR model and $u(t)$ is innovation variance. AIC is defined by

$$AIC = n \log(det(sd)) + 2k,$$

where n is the length of data, sd is the estimates of the innovation variance and k is the number of parameter.

Value

`ns`	the number of local spans.
`arcoef`	AR coefficients.
`v`	innovation variance.
`aic`	AIC.
`daic21`	= AIC2 - AIC1.
`daic`	= `daic21`$/n$ (n is the length of the current model).
`init`	start point of the data fitted to the current model.
`end`	end point of the data fitted to the current model.
`pspec`	power spectrum.

References

H.Akaike, E.Arahata and T.Ozaki (1976) *Computer Science Monograph, No.6, Timsac74 A Time Series Analysis and Control Program Package (2).* The Institute of Statistical Mathematics.

Examples

```
# Non-stationary Test Data
data(nonstData)
nonst(nonstData, span = 700, max.order = 49)
```

`nonstData` *Non-stationary Test Data*

Description

A non-stationary data for testing `nonst`.

Usage

```
data(nonstData)
```

Format

A time series of 2100 observations.

Source

H.Akaike, E.Arahata and T.Ozaki (1976) *Computer Science Monograph, No.6, Timsac74 A Time Series Analysis and Control Program Package (2).* The Institute of Statistical Mathematics.

optdes *Optimal Controller Design*

Description

Compute optimal controller gain matrix for a quadratic criterion defined by two positive definite matrices Q and R.

Usage

```
optdes(y, max.order = NULL, ns, q, r)
```

Arguments

y	a multivariate time series.
max.order	upper limit of model order. Default is $2\sqrt{n}$, where n is the length of the time series y.
ns	number of D.P. stages.
q	positive definite (m, m) matrix Q, where m is the number of controlled variables. A quadratic criterion is defined by Q and R.
r	positive definite (l, l) matrix R, where l is the number of manipulated variables.

Value

perr	prediction error covariance matrix.
trans	first m columns of transition matrix, where m is the number of controlled variables.
gamma	gamma matrix.
gain	gain matrix.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
# Multivariate Example Data
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,   0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1, 0), nrow= 3, ncol= 3, byrow = TRUE)
ar[, , 2] <- matrix(c(0,  -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow= 3, ncol= 3, byrow = TRUE)
x <- matrix(rnorm(200*3), nrow = 200, ncol = 3)
y <- mfilter(x, ar, "recursive")
q.mat <- matrix(c(0.16,0,0,0.09), nrow = 2, ncol = 2)
r.mat <- as.matrix(0.001)
optdes(y, ns = 20, q = q.mat, r = r.mat)
```

`optsim` *Optimal Control Simulation*

Description

Perform optimal control simulation and evaluate the means and variances of the controlled and manipulated variables X and Y.

Usage

```
optsim(y, max.order = NULL, ns, q, r, noise = NULL, len, plot = TRUE)
```

Arguments

`y`	a multivariate time series.
`max.order`	upper limit of model order. Default is $2\sqrt{n}$, where n is the length of the time series `y`.
`ns`	number of steps of simulation.
`q`	positive definite matrix Q.
`r`	positive definite matrix R.
`noise`	noise. If not provided, Gaussian vector white noise with the length `len` is generated.
`len`	length of white noise record.
`plot`	logical. If `TRUE` (default), controlled variables X and manipulated variables Y are plotted.

Value

`trans`	first m columns of transition matrix, where m is the number of controlled variables.
`gamma`	gamma matrix.
`gain`	gain matrix.
`convar`	controlled variables X.
`manvar`	manipulated variables Y.
`xmean`	mean of X.
`ymean`	mean of Y.
`xvar`	variance of X.
`yvar`	variance of Y.
`x2sum`	sum of X^2.
`y2sum`	sum of Y^2.
`x2mean`	mean of X^2.
`y2mean`	mean of Y^2.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
# Multivariate Example Data
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,    0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1, 0), nrow = 3, ncol = 3, byrow = TRUE)
ar[, , 2] <- matrix(c(0,  -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow = 3, ncol = 3, byrow = TRUE)
x <- matrix(rnorm(200*3), nrow = 200, ncol = 3)
y <- mfilter(x, ar, "recursive")
q.mat <- matrix(c(0.16,0,0,0.09), nrow = 2, ncol = 2)
r.mat <- as.matrix(0.001)
optsim(y, max.order = 10, ns = 20, q = q.mat, r = r.mat, len = 20)
```

---

perars *Periodic Autoregression for a Scalar Time Series*

Description

This is the program for the fitting of periodic autoregressive models by the method of least squares realized through householder transformation.

Usage

```
perars(y, ni, lag = NULL, ksw = 0)
```

Arguments

`y`	a univariate time series.
`ni`	number of instants in one period.
`lag`	maximum lag of periods. Default is $2\sqrt{\texttt{ni}}$.
`ksw`	integer. '0' denotes constant vector is not included as a regressor and '1' denotes constant vector is included as the first regressor.

Details

Periodic autoregressive model ($i = 1, \ldots, nd, j = 1, \ldots,$ `ni`) is defined by

$z(i, j) = y(ni(i - 1) + j)$,

$z(i, j) = c(j) + A(1, j, 0)z(i, 1) + \ldots + A(j - 1, j, 0)z(i, j - 1) + A(1, j, 1)z(i - 1, 1) + \ldots + A(ni, j, 1)z(i - 1, ni) + \ldots + u(i, j)$,

where nd is the number of periods, ni is the number of instants in one period and $u(i, j)$ is the Gaussian white noise. When `ksw` is set to '0', the constant term $c(j)$ is excluded.

The statistics AIC is defined by $AIC = n \log(det(v)) + 2k$, where n is the length of data, v is the estimate of the innovation variance matrix and k is the number of parameters. The outputs are the estimates of the regression coefficients and innovation variance of the periodic AR model for each instant.

Value

`mean`	mean.
`var`	variance.
`subset`	specification of i-th regressor ($i = 1, \ldots,$ni).
`regcoef`	regression coefficients.
`rvar`	residual variances.
`np`	number of parameters.
`aic`	AIC.
`v`	innovation variance matrix.
`arcoef`	AR coefficient matrices. `arcoef[i,,k]` shows i-th regressand of k-th period former.
`const`	constant vector.
`morder`	order of the MAICE model.

References

M.Pagano (1978) On Periodic and Multiple Autoregressions. Ann. Statist., 6, 1310–1317.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(Airpollution)
perars(Airpollution, ni = 6, lag = 2, ksw = 1)
```

`Powerplant` *Power Plant Data*

Description

A Power plant data for testing `mulbar` and `mulmar`.

Usage

```
data(Powerplant)
```

Format

A 2-dimensional array with 500 observations on 3 variables.

[, 1]	command
[, 2]	temperature
[, 3]	fuel

Source

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

prdctr *Prediction Program*

Description

Operate on a real record of a vector process and compute predicted values.

Usage

```
prdctr(y, r, s, h, arcoef, macoef = NULL, impulse = NULL, v, plot = TRUE)
```

Arguments

`y`	a univariate time series or a multivariate time series.
`r`	one step ahead prediction starting position R.
`s`	long range forecast starting position S.
`h`	maximum span of long range forecast H.
`arcoef`	AR coefficient matrices.
`macoef`	MA coefficient matrices.
`impulse`	impulse response matrices.
`v`	innovation variance.
`plot`	logical. If `TRUE` (default), the real data and predicted values are plotted.

Details

One step ahead Prediction starts at time R and ends at time S. Prediction is continued without new observations until time $S + H$. Basic model is the autoregressive moving average model of $y(t)$ which is given by

$$y(t) - A(t)y(t-1) - ... - A(p)y(t-p) = u(t) - B(1)u(t-1) - ... - B(q)u(t-q),$$

where p is AR order and q is MA order.

Value

`predct`	predicted values : `predct[i]` (r$\leq i \leq$s+h).
`ys`	`predct[i]` - `y[i]` (r$\leq i \leq n$).
`pstd`	`predct[i]` + (standard deviation) (s$\leq i \leq$s+h).
`p2std`	`predct[i]` + 2*(standard deviation) (s$\leq i \leq$s+h).
`p3std`	`predct[i]` + 3*(standard deviation) (s$\leq i \leq$s+h).
`mstd`	`predct[i]` - (standard deviation) (s$\leq i \leq$s+h).
`m2std`	`predct[i]` - 2*(standard deviation) (s$\leq i \leq$s+h).
`m3std`	`predct[i]` - 3*(standard deviation) (s$\leq i \leq$s+h).

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.6, Timsac74, A Time Series Analysis and Control Program Package (2).* The Institute of Statistical Mathematics.

Examples

```
# "arima.sim" is a function in "stats".
# Note that the sign of MA coefficient is opposite from that in "timsac".
y <- arima.sim(list(order=c(2,0,1), ar=c(0.64,-0.8), ma=c(-0.5)), n = 1000)
y1 <- y[1:900]
z <- autoarmafit(y1)
ar <- z$model[[1]]$arcoef
ma <- z$model[[1]]$macoef
var <- z$model[[1]]$v
y2 <- y[901:990]
prdctr(y2, r = 50, s = 90, h = 10, arcoef = ar, macoef = ma, v = var)
```

---

raspec *Rational Spectrum*

Description

Compute power spectrum of ARMA process.

Usage

```
raspec(h, var, arcoef = NULL, macoef = NULL, log = FALSE, plot = TRUE)
```

Arguments

h	specify frequencies i/2h ($i = 0, 1, \ldots$,h).
var	variance.
arcoef	AR coefficients.
macoef	MA coefficients.
log	logical. If TRUE, the spectrum is plotted as log(raspec).
plot	logical. If TRUE (default), the spectrum is plotted.

Details

ARMA process :

$$y(t) - a(1)y(t-1) - \ldots - a(p)y(t-p) = u(t) - b(1)u(t-1) - \ldots - b(q)u(t-q)$$

where p is AR order, q is MA order and $u(t)$ is a white noise with zero mean and variance equal to var.

Value

raspec gives the rational spectrum.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
# Example 1 for the AR model
raspec(h = 100, var = 1, arcoef = c(0.64,-0.8))

# Example 2 for the MA model
raspec(h = 20, var = 1, macoef = c(0.64,-0.8))
```

`sglfre` *Frequency Response Function (Single Channel)*

Description

Compute 1-input,1-output frequency response function, gain, phase, coherency and relative error statistics.

Usage

```
sglfre(y, lag = NULL, invar, outvar)
```

Arguments

`y`	a multivariate time series.
`lag`	maximum lag. Default $2\sqrt{n}$, where n is the length of the time series `y`.
`invar`	within d variables of the spectrum, `invar`-th variable is taken as an input variable.
`outvar`	within d variables of the spectrum, `outvar`-th variable is taken as an output variable .

Value

`inspec`	power spectrum (input).
`outspec`	power spectrum (output).
`cspec`	co-spectrum.
`qspec`	quad-spectrum.
`gain`	gain.
`coh`	coherency.
`freqr`	frequency response function : real part.
`freqi`	frequency response function : imaginary part.
`errstat`	relative error statistics.
`phase`	phase.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
ar <- array(0, dim = c(3,3,2))
ar[, , 1] <- matrix(c(0.4,  0,   0.3,
                      0.2, -0.1, -0.5,
                      0.3,  0.1,  0), nrow = 3, ncol = 3, byrow = TRUE)
ar[, , 2] <- matrix(c(0,   -0.3,  0.5,
                      0.7, -0.4,  1,
                      0,   -0.5,  0.3), nrow = 3, ncol = 3, byrow = TRUE)
x <- matrix(rnorm(200*3), nrow = 200, ncol = 3)
y <- mfilter(x, ar, "recursive")
sglfre(y, lag = 20, invar = 1, outvar = 2)
```

`simcon` *Optimal Controller Design and Simulation*

Description

Produce optimal controller gain and simulate the controlled process.

Usage

```
simcon(span, len, r, arcoef, impulse, v, weight)
```

Arguments

`span`	span of control performance evaluation.
`len`	length of experimental observation.
`r`	dimension of control input, less than or equal to d (dimension of a vector).
`arcoef`	matrices of autoregressive coefficients. `arcoef[i,j,k]` shows the value of i-th row, j-th column, k-th order.
`impulse`	impulse response matrices.
`v`	covariance matrix of innovation.
`weight`	weighting matrix of performance.

Details

The basic state space model is obtained from the autoregressive moving average model of a vector process $y(t)$;

$y(t) - A(1)y(t-1) - \ldots - A(p)y(t-p) = u(t) - B(1)u(t-1) - \ldots - B(p-1)u(t-p+1),$

where $A(i)$ $(i = 1, \ldots, p)$ are the autoregressive coefficients of the ARMA representation of $y(t)$.

Value

`gain`	controller gain.
`ave`	average value of i-th component of `y`.
`var`	variance.
`std`	standard deviation.
`bc`	sub matrices (pd, r) of impulse response matrices, where p is the order of the process, d is the dimension of the vector and r is the dimension of the control input.
`bd`	sub matrices $(pd, d-r)$ of impulse response matrices.

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.6, Timsac74, A Time Series Analysis and Control Program Package (2).* The Institute of Statistical Mathematics.

Examples

```
x <- matrix(rnorm(1000*2), nrow = 1000, ncol = 2)
ma <- array(0, dim = c(2,2,2))
ma[, , 1] <- matrix(c( -1.0,  0.0,
                        0.0, -1.0), nrow = 2, ncol = 2, byrow = TRUE)
ma[, , 2] <- matrix(c( -0.2,  0.0,
                       -0.1, -0.3), nrow = 2, ncol = 2, byrow = TRUE)
y <- mfilter(x, ma, "convolution")

ar <- array(0, dim = c(2,2,3))
ar[, , 1] <- matrix(c( -1.0,  0.0,
                        0.0, -1.0), nrow = 2, ncol = 2, byrow = TRUE)
ar[, , 2] <- matrix(c( -0.5, -0.2,
                       -0.2, -0.5), nrow = 2, ncol = 2, byrow = TRUE)
ar[, , 3] <- matrix(c( -0.3, -0.05,
                       -0.1, -0.3), nrow = 2, ncol = 2, byrow = TRUE)
y <- mfilter(y, ar, "recursive")

z <- markov(y)
weight <-  matrix(c(0.0002,  0.0,
                    0.0,     2.9 ), nrow = 2, ncol = 2, byrow = TRUE)
simcon(span = 50, len = 700, r = 1, z$arcoef, z$impulse, z$v, weight)
```

---

thirmo *Third Order Moments*

Description

Compute the third order moments.

Usage

```
thirmo(y, lag = NULL, plot = TRUE)
```

Arguments

`y`	a univariate time series.
`lag`	maximum lag. Default is $2\sqrt{n}$, where n is the length of the time series `y`.
`plot`	logical. If `TRUE` (default), autocovariance `acor` is plotted.

Value

`mean`	mean.
`acov`	autocovariance.
`acor`	normalized covariance.
`tmomnt`	third order moments.

References

H.Akaike, E.Arahata and T.Ozaki (1975) *Computer Science Monograph, No.6, Timsac74, A Time Series Analysis and Control Program Package (2).* The Institute of Statistical Mathematics.

Examples

```
data(bispecData)
z <- thirmo(bispecData, lag = 30)
z$tmomnt
```

`unibar` *Univariate Bayesian Method of AR Model Fitting*

Description

This program fits an autoregressive model by a Bayesian procedure. The least squares estimates of the parameters are obtained by the householder transformation.

Usage

```
unibar(y, ar.order = NULL, plot = TRUE)
```

Arguments

`y`	a univariate time series.
`ar.order`	order of the AR model. Default is $2\sqrt{n}$, where n is the length of the time series `y`.
`plot`	logical. If `TRUE` (default), `daic`, `pacoef` and `pspec` are plotted.

Details

The AR model is given by

$$y(t) = a(1)y(t-1) + \ldots + a(p)y(t-p) + u(t),$$

where p is AR order and $u(t)$ is Gaussian white noise with mean 0 and variance $v(p)$. The basic statistic AIC is defined by

$$AIC = n\log(det(v)) + 2m,$$

where n is the length of data, v is the estimate of innovation variance, and m is the order of the model.

Bayesian weight of the m-th order model is defined by

$$W(m) = CONST \times \frac{C(m)}{m+1},$$

where $CONST$ is the normalizing constant and $C(m) = \exp(-0.5AIC(m))$. The equivalent number of free parameter for the Bayesian model is defined by

$$ek = D(1)^2 + \ldots + D(k)^2 + 1,$$

where $D(j)$ is defined by $D(j) = W(j) + \ldots + W(k)$. m in the definition of AIC is replaced by ek to be define an equivalent AIC for a Bayesian model.

Value

`mean`	mean.
`var`	variance.
`v`	innovation variance.
`aic`	AIC.
`aicmin`	minimum AIC.
`daic`	AIC-`aicmin`.
`order.maice`	order of minimum AIC.
`v.maice`	innovation variance attained at m=`order.maice`.
`pacoef`	partial autocorrelation coefficients (least squares estimate).
`bweight`	Bayesian Weight.
`integra.bweight`	integrated Bayesian weights.
`v.bay`	innovation variance of Bayesian model.
`aic.bay`	AIC of Bayesian model.
`np`	equivalent number of parameters.
`pacoef.bay`	partial autocorrelation coefficients of Bayesian model.
`arcoef`	AR coefficients of Bayesian model.
`pspec`	power spectrum.

References

H.Akaike (1978) A Bayesian Extension of The Minimum AIC Procedure of Autoregressive model Fitting. Research memo. No.126. The Institute of Statistical Mathematics.

G.Kitagawa and H.Akaike (1978) A Procedure for The Modeling of Non-Stationary Time Series. Ann. Inst. Statist. Math., 30, B, 351–363.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(Canadianlynx)
z <- unibar(Canadianlynx, ar.order = 20)
z$arcoef
```

`unimar` *Univariate Case of Minimum AIC Method of AR Model Fitting*

Description

This is the basic program for the fitting of autoregressive models of successively higher by the method of least squares realized through householder transformation.

Usage

```
unimar(y, max.order = NULL, plot = FALSE)
```

Arguments

`y`	a univariate time series.
`max.order`	upper limit of AR order. Default is $2\sqrt{n}$, where n is the length of the time series y.
`plot`	logical. If `TRUE`, `daic` is plotted.

Details

The AR model is given by

$$y(t) = a(1)y(t-1) + \ldots + a(p)y(t-p) + u(t),$$

where p is AR order and $u(t)$ is Gaussian white noise with mean 0 and variance v. AIC is defined by

$$AIC = n \log(det(v)) + 2k,$$

where n is the length of data, v is the estimates of the innovation variance and k is the number of parameter.

Value

`mean`	mean.
`var`	variance.
`v`	innovation variance.
`aic`	AIC.
`aicmin`	minimum AIC.
`daic`	AIC-`aicmin`.
`order.maice`	order of minimum AIC.
`v.maice`	innovation variance attained at `order.maice`.
`arcoef`	AR coefficients.

References

G.Kitagawa and H.Akaike (1978) A Procedure For The Modeling of Non-Stationary Time Series. Ann. Inst. Statist. Math.,30, B, 351–363.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
data(Canadianlynx)
z <- unimar(Canadianlynx, max.order = 20)
z$arcoef
```

`wnoise` *White Noise Generator*

Description

Generate approximately Gaussian vector white noise.

Usage

```
wnoise(len, perr, plot = TRUE)
```

Arguments

`len`	length of white noise record.
`perr`	prediction error.
`plot`	logical. If `TRUE` (default), white noises are plotted.

Value

`wnoise` gives white noises.

References

H.Akaike and T.Nakagawa (1988) *Statistical Analysis and Control of Dynamic Systems.* Kluwer Academic publishers.

Examples

```
# Example 1
wnoise(len = 100, perr = 1)

# Example 2
v <- matrix(c(1,  0,  0,
              0,  2,  0,
              0,  0,  3), nrow = 3, ncol = 3, byrow = TRUE)
wnoise(len = 20, perr = v)
```

`xsarma` *Exact Maximum Likelihood Method of Scalar ARMA Model Fitting*

Description

Produce exact maximum likelihood estimates of the parameters of a scalar ARMA model.

Usage

```
xsarma(y, arcoefi, macoefi)
```

Arguments

`y`	a univariate time series.
`arcoefi`	initial estimates of AR coefficients.
`macoefi`	initial estimates of MA coefficients.

Details

The ARMA model is given by

$$y(t) - a(1)y(t-1) - \ldots - a(p)y(t-p) = u(t) - b(1)u(t-1) - ... - b(q)u(t-q),$$

where p is AR order, q is MA order and $u(t)$ is a zero mean white noise.

Value

`gradi`	initial gradient.
`lkhoodi`	initial (-2)log likelihood.
`arcoef`	final estimates of AR coefficients.
`macoef`	final estimates of MA coefficients.
`grad`	final gradient.
`alph.ar`	final ALPH (AR part) at subroutine ARCHCK.
`alph.ma`	final ALPH (MA part) at subroutine ARCHCK.
`lkhood`	final (-2)log likelihood.
`wnoise.var`	white noise variance.

References

H.Akaike (1978) Covariance matrix computation of the state variable of a stationary Gaussian process. Research Memo. No.139. The Institute of Statistical Mathematics.

H.Akaike, G.Kitagawa, E.Arahata and F.Tada (1979) *Computer Science Monograph, No.11, Timsac78.* The Institute of Statistical Mathematics.

Examples

```
# "arima.sim" is a function in "stats".
# Note that the sign of MA coefficient is opposite from that in "timsac".
arcoef <- c(1.45, -0.9)
macoef <- c(-0.5)
y <- arima.sim(list(order=c(2,0,1), ar=arcoef, ma=macoef), n = 100)
arcoefi <- c(1.5, -0.8)
macoefi <- c(0.0)
z <- xsarma(y, arcoefi, macoefi)
z$arcoef
z$macoef
```

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