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**Description**

Methods and tools for displaying and analysing univariate time series forecasts including exponential smoothing via state space models and automatic ARIMA modelling.

**Details**

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**Author(s)**

Rob J Hyndman

Maintainer: Rob.Hyndman@monash.edu

**accuracy**

Accuracy measures for a forecast model

**Description**

Returns range of summary measures of the forecast accuracy. If \( x \) is provided, the function measures test set forecast accuracy based on \( x-f \). If \( x \) is not provided, the function only produces training set accuracy measures of the forecasts based on \( f["x"]-\text{fitted}(f) \). All measures are defined and discussed in Hyndman and Koehler (2006).
accuracy

Usage

accuracy(object, ...)

## Default S3 method:
accuracy(object, x, test = NULL, d = NULL, D = NULL, f = NULL, ...)

Arguments

- **object**: An object of class “forecast”, or a numerical vector containing forecasts. It will also work with Arima, ets and lm objects if x is omitted – in which case training set accuracy measures are returned.
- **...**: Additional arguments depending on the specific method.
- **x**: An optional numerical vector containing actual values of the same length as object, or a time series overlapping with the times of f.
- **test**: Indicator of which elements of x and f to test. If test is NULL, all elements are used. Otherwise test is a numeric vector containing the indices of the elements to use in the test.
- **d**: An integer indicating the number of lag-1 differences to be used for the denominator in MASE calculation. Default value is 1 for non-seasonal series and 0 for seasonal series.
- **D**: An integer indicating the number of seasonal differences to be used for the denominator in MASE calculation. Default value is 0 for non-seasonal series and 1 for seasonal series.
- **f**: Deprecated. Please use 'object' instead.

Details

The measures calculated are:

- **ME**: Mean Error
- **RMSE**: Root Mean Squared Error
- **MAE**: Mean Absolute Error
- **MPE**: Mean Percentage Error
- **MAPE**: Mean Absolute Percentage Error
- **MASE**: Mean Absolute Scaled Error
- **ACF1**: Autocorrelation of errors at lag 1.

By default, the MASE calculation is scaled using MAE of training set naive forecasts for non-seasonal time series, training set seasonal naive forecasts for seasonal time series and training set mean forecasts for non-time series data. If f is a numerical vector rather than a forecast object, the MASE will not be returned as the training data will not be available.

See Hyndman and Koehler (2006) and Hyndman and Athanasopoulos (2014, Section 2.5) for further details.
Value

Matrix giving forecast accuracy measures.

Author(s)

Rob J Hyndman

References


Examples

```r
fit1 <- rwf(EuStockMarkets[1:200, 1], h = 100)
fit2 <- meanf(EuStockMarkets[1:200, 1], h = 100)
accuracy(fit1)
accuracy(fit2)
accuracy(fit1, EuStockMarkets[201:300, 1])
accuracy(fit2, EuStockMarkets[201:300, 1])
plot(fit1)
lines(EuStockMarkets[1:300, 1])
```

Acf

*(Partial) Autocorrelation and Cross-Correlation Function Estimation*

Description

The function Acf computes (and by default plots) an estimate of the autocorrelation function of a (possibly multivariate) time series. Function Pacf computes (and by default plots) an estimate of the partial autocorrelation function of a (possibly multivariate) time series. Function Ccf computes the cross-correlation or cross-covariance of two univariate series.

Usage

```r
Acf(
  x,
  lag.max = NULL,
  type = c("correlation", "covariance", "partial"),
  plot = TRUE,
  na.action = na.contiguous,
  demean = TRUE,
  ...)
```
Acf

Pacf(
x,  
lag.max = NULL,  
plot = TRUE,  
na.action = na.contiguous,  
demean = TRUE,
...
)

Ccf(
x,  
y,  
lag.max = NULL,  
type = c("correlation", "covariance"),  
plot = TRUE,  
na.action = na.contiguous,
...
)

taperedacf(
x,  
lag.max = NULL,  
type = c("correlation", "partial"),  
plot = TRUE,  
calc.ci = TRUE,  
level = 95,  
nsim = 100,
...
)

taperedpacf(x, ...)

Arguments

x  a univariate or multivariate (not Ccf) numeric time series object or a numeric vector or matrix.
lag.max  maximum lag at which to calculate the acf. Default is $10*\log_{10}(N/m)$ where $N$ is the number of observations and $m$ the number of series. Will be automatically limited to one less than the number of observations in the series.
type  character string giving the type of acf to be computed. Allowed values are "correlation" (the default), "covariance" or "partial".
plot  logical. If TRUE (the default) the resulting acf, pacf or ccf is plotted.
na.action  function to handle missing values. Default is na.contiguous. Useful alternatives are na.pass and na.interp.
demean  Should covariances be about the sample means?
...  Additional arguments passed to the plotting function.
y  a univariate numeric time series object or a numeric vector.
calc.ci: If TRUE, confidence intervals for the ACF/PACF estimates are calculated.
level: Percentage level used for the confidence intervals.
nsim: The number of bootstrap samples used in estimating the confidence intervals.

Details
The functions improve the `acf`, `pacf` and `ccf` functions. The main differences are that `Acf` does not plot a spike at lag 0 when `type=="correlation"` (which is redundant) and the horizontal axes show lags in time units rather than seasonal units.

The tapered versions implement the ACF and PACF estimates and plots described in Hyndman (2015), based on the banded and tapered estimates of autocovariance proposed by McMurry and Politis (2010).

Value
The `Acf`, `Pacf` and `Ccf` functions return objects of class "acf" as described in `acf` from the stats package. The `taperedacf` and `taperedpacf` functions return objects of class "mpacf".

Author(s)
Rob J Hyndman

References

See Also
`acf`, `pacf`, `ccf`, `tsdisplay`

Examples
```r
Acf(wineind)
Pacf(wineind)
## Not run:
taperedacf(wineind, nsim=50)
taperedpacf(wineind, nsim=50)
## End(Not run)
```
arfima

Fit a fractionally differenced ARFIMA model

Description

An ARFIMA(p,d,q) model is selected and estimated automatically using the Hyndman-Khandakar
(2008) algorithm to select p and q and the Haslett and Raftery (1989) algorithm to estimate the
parameters including d.

Usage

arfima(
y, 
   drange = c(0, 0.5),
   estim = c("mle", "ls"),
   model = NULL,
   lambda = NULL,
   biasadj = FALSE,
   x = y,
   ...
)

Arguments

y a univariate time series (numeric vector).

 drange Allowable values of d to be considered. Default of c(0,0.5) ensures a station-
ary model is returned.

 estim If estim="ls", then the ARMA parameters are calculated using the Haslett-
Raftery algorithm. If estim="mle", then the ARMA parameters are calculated
using full MLE via the arima function.

 model Output from a previous call to arfima. If model is passed, this same model is
fitted to y without re-estimating any parameters.

 lambda Box-Cox transformation parameter. If lambda="auto", then a transformation is
automatically selected using BoxCox.lambda. The transformation is ignored if
NULL. Otherwise, data transformed before model is estimated.

 biasadj Use adjusted back-transformed mean for Box-Cox transformations. If trans-
formed data is used to produce forecasts and fitted values, a regular back trans-
formation will result in median forecasts. If biasadj is TRUE, an adjustment will
be made to produce mean forecasts and fitted values.

 x Deprecated. Included for backwards compatibility.

 ... Other arguments passed to auto.arima when selecting p and q.
Details

This function combines \texttt{fracdiff} and \texttt{auto.arima} to automatically select and estimate an ARFIMA model. The fractional differencing parameter is chosen first assuming an ARFIMA(2,d,0) model. Then the data are fractionally differenced using the estimated d and an ARMA model is selected for the resulting time series using \texttt{auto.arima}. Finally, the full ARFIMA(p,d,q) model is re-estimated using \texttt{fracdiff}. If \texttt{estim=="mle"}, the ARMA coefficients are refined using \texttt{arima}.

Value

A list object of S3 class "fracdiff", which is described in the \texttt{fracdiff} documentation. A few additional objects are added to the list including \texttt{x} (the original time series), and the residuals and fitted values.

Author(s)

Rob J Hyndman and Farah Yasmeen

References


See Also

\texttt{fracdiff}, \texttt{auto.arima}, \texttt{forecast.fracdiff}.

Examples

```r
library(fracdiff)
x <- fracdiff.sim(100, ma=-.4, d=.3)$series
fit <- arfima(x)
tsdisplay(residuals(fit))
```

\begin{center}
\begin{tabular}{ll}
\textbf{Arima} & \textit{Fit ARIMA model to univariate time series} \\
\end{tabular}
\end{center}

Description

Largely a wrapper for the \texttt{arima} function in the stats package. The main difference is that this function allows a drift term. It is also possible to take an ARIMA model from a previous call to \texttt{Arima} and re-apply it to the data \texttt{y}. 
Usage

Arima(
  y,
  order = c(0, 0, 0),
  seasonal = c(0, 0, 0),
  xreg = NULL,
  include.mean = TRUE,
  include.drift = FALSE,
  include.constant,
  lambda = model$lambda,
  biasadj = FALSE,
  method = c("CSS-ML", "ML", "CSS"),
  model = NULL,
  x = y,
  ...
)

Arguments

y a univariate time series of class ts.
order A specification of the non-seasonal part of the ARIMA model: the three components (p, d, q) are the AR order, the degree of differencing, and the MA order.
seasonal A specification of the seasonal part of the ARIMA model, plus the period (which defaults to frequency(y)). This should be a list with components order and period, but a specification of just a numeric vector of length 3 will be turned into a suitable list with the specification as the order.
xreg Optionally, a numerical vector or matrix of external regressors, which must have the same number of rows as y. It should not be a data frame.
include.mean Should the ARIMA model include a mean term? The default is TRUE for undifferenced series, FALSE for differenced ones (where a mean would not affect the fit nor predictions).
include.drift Should the ARIMA model include a linear drift term? (i.e., a linear regression with ARIMA errors is fitted.) The default is FALSE.
include.constant If TRUE, then include.mean is set to be TRUE for undifferenced series and include.drift is set to be TRUE for differenced series. Note that if there is more than one difference taken, no constant is included regardless of the value of this argument. This is deliberate as otherwise quadratic and higher order polynomial trends would be induced.
lambda Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
biasadj Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.
method  Fitting method: maximum likelihood or minimize conditional sum-of-squares. The default (unless there are missing values) is to use conditional-sum-of-squares to find starting values, then maximum likelihood.

model  Output from a previous call to Arima. If model is passed, this same model is fitted to y without re-estimating any parameters.

x  Deprecated. Included for backwards compatibility.

...  Additional arguments to be passed to arima.

Details  See the arima function in the stats package.

Value  See the arima function in the stats package. The additional objects returned are

x  The time series data

xreg  The regressors used in fitting (when relevant).

sigma2  The bias adjusted MLE of the innovations variance.

Author(s)  Rob J Hyndman

See Also  auto.arima, forecast.Arima.

Examples  library(ggplot2)
WWWusage %>%
  Arima(order=c(3,1,0)) %>%
  forecast(h=20) %>%
  autoplot

# Fit model to first few years of AirPassengers data
air.model <- Arima(window(AirPassengers, end=1956+11/12), order=c(0,1,1),
  seasonal=list(order=c(0,1,1), period=12), lambda=0)
plot(forecast(air.model, h=48))
lines(AirPassengers)

# Apply fitted model to later data
air.model2 <- Arima(window(AirPassengers, start=1957), model=air.model)

# Forecast accuracy measures on the log scale.
# In-sample one-step forecasts.
accuracy(air.model)
# Out-of-sample one-step forecasts.
accuracy(air.model2)
arima.errors  Errors from a regression model with ARIMA errors

Description
Returns time series of the regression residuals from a fitted ARIMA model.

Usage

arima.errors(object)

Arguments

object
An object containing a time series model of class Arima.

Details
This is a deprecated function which is identical to residuals.Arima(object, type="regression")
Regression residuals are equal to the original data minus the effect of any regression variables. If there are no regression variables, the errors will be identical to the original series (possibly adjusted to have zero mean).

Value
A ts object

Author(s)
Rob J Hyndman

See Also
residuals.Arima.
arimaorder

Return the order of an ARIMA or ARFIMA model

Description

Returns the order of a univariate ARIMA or ARFIMA model.

Usage

arimaorder(object)

Arguments

object 
An object of class “Arima”, dQuotear or “fracdiff”. Usually the result of a call to arima, Arima, auto.arima, ar, arfima or fracdiff.

Value

A numerical vector giving the values $p$, $d$ and $q$ of the ARIMA or ARFIMA model. For a seasonal ARIMA model, the returned vector contains the values $p$, $d$, $q$, $P$, $D$, $Q$ and $m$, where $m$ is the period of seasonality.

Author(s)

Rob J Hyndman

See Also

ar, auto.arima, Arima, arima, arfima.

Examples

WWWusage %>% auto.arima %>% arimaorder

auto.arima

Fit best ARIMA model to univariate time series

Description

Returns best ARIMA model according to either AIC, AICc or BIC value. The function conducts a search over possible model within the order constraints provided.
Usage

auto.arima(
    y,
    d = NA,
    D = NA,
    max.p = 5,
    max.q = 5,
    max.P = 2,
    max.Q = 2,
    max.order = 5,
    max.d = 2,
    max.D = 1,
    start.p = 2,
    start.q = 2,
    start.P = 1,
    start.Q = 1,
    stationary = FALSE,
    seasonal = TRUE,
    ic = c("aicc", "aic", "bic"),
    stepwise = TRUE,
    nmodels = 94,
    trace = FALSE,
    approximation = (length(x) > 150 | frequency(x) > 12),
    method = NULL,
    truncate = NULL,
    xreg = NULL,
    test = c("kpss", "adf", "pp"),
    test.args = list(),
    seasonal.test = c("seas", "ocsb", "hegy", "ch"),
    seasonal.test.args = list(),
    allowdrift = TRUE,
    allowmean = TRUE,
    lambda = NULL,
    biasadj = FALSE,
    parallel = FALSE,
    num.cores = 2,
    x = y,
    ...
)

Arguments

y 
    a univariate time series

d 
    Order of first-differencing. If missing, will choose a value based on test.

D 
    Order of seasonal-differencing. If missing, will choose a value based on season.test.

max.p 
    Maximum value of p

max.q 
    Maximum value of q
max.P Maximum value of P
max.Q Maximum value of Q
max.order Maximum value of p+q+P+Q if model selection is not stepwise.
max.d Maximum number of non-seasonal differences
max.D Maximum number of seasonal differences
start.p Starting value of p in stepwise procedure.
start.q Starting value of q in stepwise procedure.
start.P Starting value of P in stepwise procedure.
start.Q Starting value of Q in stepwise procedure.
stationary If TRUE, restricts search to stationary models.
seasonal If FALSE, restricts search to non-seasonal models.
ic Information criterion to be used in model selection.
stepwise If TRUE, will do stepwise selection (faster). Otherwise, it searches over all models. Non-stepwise selection can be very slow, especially for seasonal models.
nmodels Maximum number of models considered in the stepwise search.
trace If TRUE, the list of ARIMA models considered will be reported.
approximation If TRUE, estimation is via conditional sums of squares and the information criteria used for model selection are approximated. The final model is still computed using maximum likelihood estimation. Approximation should be used for long time series or a high seasonal period to avoid excessive computation times.
method fitting method: maximum likelihood or minimize conditional sum-of-squares. The default (unless there are missing values) is to use conditional-sum-of-squares to find starting values, then maximum likelihood. Can be abbreviated.
truncate An integer value indicating how many observations to use in model selection. The last truncate values of the series are used to select a model when truncate is not NULL and approximation=TRUE. All observations are used if either truncate=NULL or approximation=FALSE.
xreg Optionally, a numerical vector or matrix of external regressors, which must have the same number of rows as y. (It should not be a data frame.)
test Type of unit root test to use. See ndiffs for details.
test.args Additional arguments to be passed to the unit root test.
seasonal.test This determines which method is used to select the number of seasonal differences. The default method is to use a measure of seasonal strength computed from an STL decomposition. Other possibilities involve seasonal unit root tests.
seasonal.test.args Additional arguments to be passed to the seasonal unit root test. See nsdiffs for details.
allowdrift If TRUE, models with drift terms are considered.
allowmean If TRUE, models with a non-zero mean are considered.
lambda Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
auto.arima

biasadj
Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

parallel
If TRUE and stepwise = FALSE, then the specification search is done in parallel. This can give a significant speedup on multicore machines.

num.cores
Allows the user to specify the amount of parallel processes to be used if parallel = TRUE and stepwise = FALSE. If NULL, then the number of logical cores is automatically detected and all available cores are used.

x
Deprecated. Included for backwards compatibility.

Additional arguments to be passed to arima.

Details
The default arguments are designed for rapid estimation of models for many time series. If you are analysing just one time series, and can afford to take some more time, it is recommended that you set stepwise=FALSE and approximation=FALSE.

Non-stepwise selection can be slow, especially for seasonal data. The stepwise algorithm outlined in Hyndman & Khandakar (2008) is used except that the default method for selecting seasonal differences is now based on an estimate of seasonal strength (Wang, Smith & Hyndman, 2006) rather than the Canova-Hansen test. There are also some other minor variations to the algorithm described in Hyndman and Khandakar (2008).

Value
Same as for Arima

Author(s)
Rob J Hyndman

References


See Also
Arima

Examples
fit <- auto.arima(WWWusage)
plot(forecast(fit,h=20))
autolayer

Description

autolayer() uses ggplot2 to draw a particular layer for an object of a particular class in a single command. This defines the S3 generic that other classes and packages can extend.

Usage

autolayer(object, ...)

Arguments

object an object, whose class will determine the behaviour of autolayer

... other arguments passed to specific methods

Value

a ggplot layer

See Also

autoplot(), ggplot() and fortify()

autolayer.mts

Automatically create a ggplot for time series objects

Description

autoplot takes an object of type ts or mts and creates a ggplot object suitable for usage with stat_forecast.

Usage

## S3 method for class 'mts'
autolayer(object, colour = TRUE, series = NULL, ...)

## S3 method for class 'msts'
autolayer(object, series = NULL, ...)

## S3 method for class 'ts'
autolayer(object, colour = TRUE, series = NULL, ...)

## S3 method for class 'ts'

autoplot(
  object,
  series = NULL,
  xlab = "Time",
  ylab = deparse(substitute(object)),
  main = NULL,
  ...)

## S3 method for class 'mts'
autoplot(
  object,
  colour = TRUE,
  facets = FALSE,
  xlab = "Time",
  ylab = deparse(substitute(object)),
  main = NULL,
  ...)

## S3 method for class 'msts'
autoplot(object, ...)

## S3 method for class 'ts'
fortify(model, data, ...)

Arguments

object Object of class “ts” or “mts”.
colour If TRUE, the time series will be assigned a colour aesthetic
series Identifies the time series with a colour, which integrates well with the functionality of geom_forecast.
... Other plotting parameters to affect the plot.
xlab X-axis label.
ylab Y-axis label.
main Main title.
facets If TRUE, multiple time series will be faceted (and unless specified, colour is set to FALSE). If FALSE, each series will be assigned a colour.
model Object of class “ts” to be converted to “data.frame”.
data Not used (required for fortify method)

Details

fortify.ts takes a ts object and converts it into a data frame (for usage with ggplot2).
Value
None. Function produces a ggplot graph.

Author(s)
Mitchell O’Hara-Wild

See Also
plot.ts, fortify

Examples

library(ggplot2)
autoplot(USAccDeaths)

lungDeaths <- cbind(mdeaths, fdeaths)
autoplot(lungDeaths)
autoplot(lungDeaths, facets=TRUE)

Description
Produces a ggplot object of their equivalent Acf, Pacf, Ccf, taperedacf and taperedpacf functions.

Usage

## S3 method for class 'acf'
autoplot(object, ci = 0.95, ...)

ggAcf(
  x,
  lag.max = NULL,
  type = c("correlation", "covariance", "partial"),
  plot = TRUE,
  na.action = na.contiguous,
  demean = TRUE,
  ...)

ggPacf(
  x,
  lag.max = NULL,
autoplot.acf

plot = TRUE,
na.action = na.contiguous,
demean = TRUE,
...
)

ggCcf(
x,
y,
lag.max = NULL,
type = c("correlation", "covariance"),
plot = TRUE,
na.action = na.contiguous,
...
)

## S3 method for class 'mpacf'
autoplot(object, ...)

ggtaperedacf(
x,
lag.max = NULL,
type = c("correlation", "partial"),
plot = TRUE,
calc.ci = TRUE,
level = 95,
nsim = 100,
...
)

ggtaperedpacf(x, ...)

Arguments

object Object of class “acf”.

.ci coverage probability for confidence interval. Plotting of the confidence interval
is suppressed if ci is zero or negative.

... Other plotting parameters to affect the plot.

x a univariate or multivariate (not Ccf) numeric time series object or a numeric
vector or matrix.

lag.max maximum lag at which to calculate the acf.

type character string giving the type of acf to be computed. Allowed values are
"correlation" (the default), "covariance" or “partial”.

plot logical. If TRUE (the default) the resulting ACF, PACF or CCF is plotted.

na.action function to handle missing values. Default is na.contiguous. Useful alterna-
tives are na.pass and na.interp.
autoplot.decomposed.ts

demean Should covariances be about the sample means?
y a univariate numeric time series object or a numeric vector. calc.ci If TRUE, confidence intervals for the ACF/PACF estimates are calculated. level Percentage level used for the confidence intervals. nsim The number of bootstrap samples used in estimating the confidence intervals.

Details

If autoplot is given an acf or mpacf object, then an appropriate ggplot object will be created.

ggtaperedpacf

Value

A ggplot object.

Author(s)

Mitchell O’Hara-Wild

See Also

plot.acf, Acf, acf, taperedacf

Examples

```r
library(ggplot2)
ggAcf(wineind)
wineind %>% Acf(plot=FALSE) %>% autoplot
## Not run:
wineind %>% taperedacf(plot=FALSE) %>% autoplot
ggtaperedacf(wineind)
ggtaperedpacf(wineind)
## End(Not run)
ggCcf(mdeaths, fdeaths)
```

---

autoplot.decomposed.ts

*Plot time series decomposition components using ggplot*

Description

Produces a ggplot object of seasonally decomposed time series for objects of class “stl” (created with stl), class “seas” (created with seas), or class “decomposed.ts” (created with decompose).
Usage

```r
## S3 method for class 'decomposed.ts'
autoplot(object, labels = NULL, range.bars = NULL, ...)

## S3 method for class 'stl'
autoplot(object, labels = NULL, range.bars = TRUE, ...)

## S3 method for class 'StructTS'
autoplot(object, labels = NULL, range.bars = TRUE, ...)

## S3 method for class 'seas'
autoplot(object, labels = NULL, range.bars = NULL, ...)

## S3 method for class 'mstl'
autoplot(object, ...)
```

Arguments

- `object`: Object of class "seas", "stl", or "decomposed.ts".
- `labels`: Labels to replace "seasonal", "trend", and "remainder".
- `range.bars`: Logical indicating if each plot should have a bar at its right side representing relative size. If NULL, automatic selection takes place.
- `...`: Other plotting parameters to affect the plot.

Value

Returns an object of class ggplot.

Author(s)

Mitchell O’Hara-Wild

See Also

`seas, stl, decompose, StructTS, plot.stl`.

Examples

```r
library(ggplot2)
co2 %>%
  decompose() %>%
  autoplot()
nottem %>%
  stl(s.window = "periodic") %>%
  autoplot()
## Not run:
library(seasonal)
seas(USAccDeaths) %>% autoplot()
```
Description

Plots historical data with multivariate forecasts and prediction intervals.

Usage

```r
## S3 method for class 'mforecast'
autoplot(object, PI = TRUE, facets = TRUE, colour = FALSE, ...)
## S3 method for class 'mforecast'
autolayer(object, series = NULL, PI = TRUE, ...)
## S3 method for class 'mforecast'
plot(x, main = paste("Forecasts from", unique(x$method)), xlab = "time", ...)
```

Arguments

- `object`: Multivariate forecast object of class `mforecast`. Used for ggplot graphics (S3 method consistency).
- `PI`: If FALSE, confidence intervals will not be plotted, giving only the forecast line.
- `facets`: If TRUE, multiple time series will be faceted. If FALSE, each series will be assigned a colour.
- `colour`: If TRUE, the time series will be assigned a colour aesthetic
- `...`: additional arguments to each individual `plot`.
- `series`: Matches an unidentified forecast layer with a coloured object on the plot.
- `x`: Multivariate forecast object of class `mforecast`.
- `main`: Main title. Default is the forecast method. For `autoplot`, specify a vector of titles for each plot.
- `xlab`: X-axis label. For `autoplot`, specify a vector of labels for each plot.

Details

`autoplot` will produce an equivalent plot as a ggplot object.

Author(s)

Mitchell O'Hara-Wild
baggedModel

Forecasting using a bagged model

Description

The bagged model forecasting method.

Usage

baggedModel(y, bootstrapped_series = bld.mbb.bootstrap(y, 100), fn = ets, ...)

baggedETS(y, bootstrapped_series = bld.mbb.bootstrap(y, 100), ...)

Arguments

y A numeric vector or time series of class ts.
bootstrapped_series bootstrapped versions of y.
fn the forecast function to use. Default is ets.
...

References


See Also

plot.forecast, plot.ts

Examples

library(ggplot2)

lungDeaths <- cbind(mdeaths, fdeaths)
fit <- tslm(lungDeaths ~ trend + season)
fcast <- forecast(fit, h=10)
plot(fcast)
autoplot(fcast)

carPower <- as.matrix(mtcars[,c("qsec","hp")])
carmpg <- mtcars[,"mpg"]
fit <- lm(carPower ~ carmpg)
fcast <- forecast(fit, newdata=data.frame(carmpg=30))
plot(fcast, xlab="Year")
autoplot(fcast, xlab=rep("Year",2))
This function implements the bagged model forecasting method described in Bergmeir et al. By default, the ets function is applied to all bootstrapped series. Base models other than ets can be given by the parameter fn. Using the default parameters, the function bld.mbb.bootstrap is used to calculate the bootstrapped series with the Box-Cox and Loess-based decomposition (BLD) bootstrap. The function forecast.baggedModel can then be used to calculate forecasts.

baggedETS is a wrapper for baggedModel, setting fn to "ets". This function is included for backwards compatibility only, and may be deprecated in the future.

Value

Returns an object of class "baggedModel".

The function print is used to obtain and print a summary of the results.

models A list containing the fitted ensemble models.
method The function for producing a forecastable model.
y The original time series.
bootstrapped_series The bootstrapped series.
modelargs The arguments passed through to fn.
fitted Fitted values (one-step forecasts). The mean of the fitted values is calculated over the ensemble.
residuals Original values minus fitted values.

Author(s)

Christoph Bergmeir, Fotios Petropoulos

References


Examples

```r
fit <- baggedModel(WWWusage)
fcast <- forecast(fit)
plot(fcast)
```
**bats**  
*BATS model (Exponential smoothing state space model with Box-Cox transformation, ARMA errors, Trend and Seasonal components)*

**Description**

Fits a BATS model applied to \( y \), as described in De Livera, Hyndman & Snyder (2011). Parallel processing is used by default to speed up the computations.

**Usage**

```r
bats(
  y,
  use.box.cox = NULL,
  use.trend = NULL,
  use.damped.trend = NULL,
  seasonal.periods = NULL,
  use.arma.errors = TRUE,
  use.parallel = length(y) > 1000,
  num.cores = 2,
  bc.lower = 0,
  bc.upper = 1,
  biasadj = FALSE,
  model = NULL,
  ...
)
```

**Arguments**

- **\( y \)**: The time series to be forecast. Can be numeric, msts or ts. Only univariate time series are supported.
- **use.box.cox**: TRUE/FALSE indicates whether to use the Box-Cox transformation or not. If NULL then both are tried and the best fit is selected by AIC.
- **use.trend**: TRUE/FALSE indicates whether to include a trend or not. If NULL then both are tried and the best fit is selected by AIC.
- **use.damped.trend**: TRUE/FALSE indicates whether to include a damping parameter in the trend or not. If NULL then both are tried and the best fit is selected by AIC.
- **seasonal.periods**: If \( y \) is a numeric then seasonal periods can be specified with this parameter.
- **use.arma.errors**: TRUE/FALSE indicates whether to include ARMA errors or not. If TRUE the best fit is selected by AIC. If FALSE then the selection algorithm does not consider ARMA errors.
- **use.parallel**: TRUE/FALSE indicates whether or not to use parallel processing.
num.cores
The number of parallel processes to be used if using parallel processing. If NULL then the number of logical cores is detected and all available cores are used.

bc.lower
The lower limit (inclusive) for the Box-Cox transformation.

bc.upper
The upper limit (inclusive) for the Box-Cox transformation.

biasadj
Use adjusted back-transformed mean for Box-Cox transformations. If TRUE, point forecasts and fitted values are mean forecast. Otherwise, these points can be considered the median of the forecast densities.

model
Output from a previous call to bats. If model is passed, this same model is fitted to y without re-estimating any parameters.

Additional arguments to be passed to auto.arima when choose an ARMA(p, q) model for the errors. (Note that xreg will be ignored, as will any arguments concerning seasonality and differencing, but arguments controlling the values of p and q will be used.)

Value
An object of class "bats". The generic accessor functions fitted.values and residuals extract useful features of the value returned by bats and associated functions. The fitted model is designated BATS(omega, p,q, phi, m1,...mJ) where omega is the Box-Cox parameter and phi is the damping parameter; the error is modelled as an ARMA(p,q) process and m1,...,mJ list the seasonal periods used in the model.

Author(s)
Slava Razbash and Rob J Hyndman

References

Examples
```r
## Not run:
fit <- bats(USAccDeaths)
plot(forecast(fit))
taylor.fit <- bats(taylor)
plot(forecast(taylor.fit))
## End(Not run)
```
Description

Returns number of trading days in each month or quarter of the observed time period in a major financial center.

Usage

```r
bizdays(x, FinCenter = c("New York", "London", "NERC", "Tokyo", "Zurich"))
```

Arguments

- `x`: Monthly or quarterly time series
- `FinCenter`: Major financial center.

Details

Useful for trading days length adjustments. More on how to define "business days", please refer to `isBizday`.

Value

Time series

Author(s)

Earo Wang

See Also

`monthdays`

Examples

```r
x <- ts(rnorm(30), start = c(2013, 2), frequency = 12)
bizdays(x, FinCenter = "New York")
```
bld.mbb.bootstrap  \hspace{1em} \textit{Box-Cox and Loess-based decomposition bootstrap.}

Description

Generates bootstrapped versions of a time series using the Box-Cox and Loess-based decomposition bootstrap.

Usage

\texttt{bld.mbb.bootstrap(x, num, block\_size = NULL)}

Arguments

\texttt{x} \hspace{1em} \text{Original time series.}
\texttt{num} \hspace{1em} \text{Number of bootstrapped versions to generate.}
\texttt{block\_size} \hspace{1em} \text{Block size for the moving block bootstrap.}

Details

The procedure is described in Bergmeir et al. Box-Cox decomposition is applied, together with STL or Loess (for non-seasonal time series), and the remainder is bootstrapped using a moving block bootstrap.

Value

A list with bootstrapped versions of the series. The first series in the list is the original series.

Author(s)

Christoph Bergmeir, Fotios Petropoulos

References


See Also

\texttt{baggedETS}.

Examples

\texttt{bootstrapped\_series <- bld.mbb.bootstrap(WWWusage, 100)}
BoxCox

BoxCox

BoxCox()

Description

BoxCox() returns a transformation of the input variable using a Box-Cox transformation. InvBoxCox() reverses the transformation.

Usage

BoxCox(x, lambda)

InvBoxCox(x, lambda, biasadj = FALSE, fvar = NULL)

Arguments

x

a numeric vector or time series of class ts.

lambda

transformation parameter. If lambda = "auto", then the transformation parameter lambda is chosen using BoxCox.lambda (with a lower bound of -0.9)

biasadj

Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

fvar

Optional parameter required if biasadj=TRUE. Can either be the forecast variance, or a list containing the interval level, and the corresponding upper and lower intervals.

Details

The Box-Cox transformation (as given by Bickel & Doksum 1981) is given by

\[ f_\lambda(x) = \text{sign}(x)(|x|^\lambda - 1)/\lambda \]

if \( \lambda \neq 0 \). For \( \lambda = 0 \),

\[ f_0(x) = \log(x) \]

Value

a numeric vector of the same length as x.

Author(s)

Rob J Hyndman & Mitchell O’Hara-Wild
References


See Also

`BoxCox.lambda`

Examples

```r
lambda <- BoxCox.lambda(lynx)
lynx.fit <- ar(BoxCox(lynx,lambda))
plot(forecast(lynx.fit,h=20,lambda=lambda))
```

BoxCox.lambda  
Automatic selection of Box Cox transformation parameter

Description

If `method=="guerrero"`, Guerrero’s (1993) method is used, where lambda minimizes the coefficient of variation for subseries of x.

Usage

`BoxCox.lambda(x, method = c("guerrero", "loglik"), lower = -1, upper = 2)`

Arguments

- `x` a numeric vector or time series of class `ts`
- `method` Choose method to be used in calculating lambda.
- `lower` Lower limit for possible lambda values.
- `upper` Upper limit for possible lambda values.

Details

If `method=="loglik"`, the value of lambda is chosen to maximize the profile log likelihood of a linear model fitted to x. For non-seasonal data, a linear time trend is fitted while for seasonal data, a linear time trend with seasonal dummy variables is used.

Value

a number indicating the Box-Cox transformation parameter.

Author(s)

Leanne Chhay and Rob J Hyndman
References


See Also

BoxCox

Examples

```r
lambda <- BoxCox.lambda(AirPassengers, lower=0)
air.fit <- Arima(AirPassengers, order=c(0,1,1),
                 seasonal=list(order=c(0,1,1), period=12), lambda=lambda)
plot(forecast(air.fit))
```

checkresiduals

Check that residuals from a time series model look like white noise

Description

If plot=TRUE, produces a time plot of the residuals, the corresponding ACF, and a histogram. If the degrees of freedom for the model can be determined and test is not FALSE, the output from either a Ljung-Box test or Breusch-Godfrey test is printed.

Usage

```r
checkresiduals(object, lag, df = NULL, test, plot = TRUE, ...)
```

Arguments

- **object**: Either a time series model, a forecast object, or a time series (assumed to be residuals).
- **lag**: Number of lags to use in the Ljung-Box or Breusch-Godfrey test. If missing, it is set to \(\min(10,n/5)\) for non-seasonal data, and \(\min(2m,n/5)\) for seasonal data, where \(n\) is the length of the series, and \(m\) is the seasonal period of the data. It is further constrained to be at least \(df+3\) where \(df\) is the degrees of freedom of the model. This ensures there are at least 3 degrees of freedom used in the chi-squared test.
- **df**: Number of degrees of freedom for fitted model, required for the Ljung-Box or Breusch-Godfrey test. Ignored if the degrees of freedom can be extracted from object.
- **test**: Test to use for serial correlation. By default, if object is of class *lm*, then test="BG". Otherwise, test="LB". Setting test=FALSE will prevent the test results being printed.
croston

plot Logical. If TRUE, will produce the plot.

... Other arguments are passed to ggttsdisplay.

Value
None

Author(s)
Rob J Hyndman

See Also
ggttsdisplay, Box.test, bgtest

Examples

fit <- ets(WWWusage)
checkresiduals(fit)

croston Forecasts for intermittent demand using Croston's method

Description

Returns forecasts and other information for Croston’s forecasts applied to y.

Usage

croston(y, h = 10, alpha = 0.1, x = y)

Arguments

y a numeric vector or time series of class ts
h Number of periods for forecasting.
alpha Value of alpha. Default value is 0.1.
x Deprecated. Included for backwards compatibility.

Details

Based on Croston’s (1972) method for intermittent demand forecasting, also described in Shenstone and Hyndman (2005). Croston’s method involves using simple exponential smoothing (SES) on the non-zero elements of the time series and a separate application of SES to the times between non-zero elements of the time series. The smoothing parameters of the two applications of SES are assumed to be equal and are denoted by alpha.

Note that prediction intervals are not computed as Croston’s method has no underlying stochastic model.
Value

An object of class "forecast" is a list containing at least the following elements:

- **model**: A list containing information about the fitted model. The first element gives the model used for non-zero demands. The second element gives the model used for times between non-zero demands. Both elements are of class `forecast`.
- **method**: The name of the forecasting method as a character string.
- **mean**: Point forecasts as a time series.
- **x**: The original time series (either `object` itself or the time series used to create the model stored as `object`).
- **residuals**: Residuals from the fitted model. That is `y` minus fitted values.
- **fitted**: Fitted values (one-step forecasts).

The function `summary` is used to obtain and print a summary of the results, while the function `plot` produces a plot of the forecasts.

The generic accessor functions `fitted.values` and `residuals` extract useful features of the value returned by `croston` and associated functions.

Author(s)

Rob J Hyndman

References


See Also

`ses`.

Examples

```r
y <- rpois(20,lambda=.3)
fcast <- croston(y)
plot(fcast)
```
Cross-validation statistic

Description

Computes the leave-one-out cross-validation statistic (the mean of PRESS – prediction residual sum of squares), AIC, corrected AIC, BIC and adjusted R^2 values for a linear model.

Usage

CV(obj)

Arguments

obj output from \texttt{lm} or \texttt{tslm}

Value

Numerical vector containing CV, AIC, AICc, BIC and AdjR2 values.

Author(s)

Rob J Hyndman

See Also

AIC

Examples

\begin{verbatim}
y <- ts(rnorm(120,0,3) + 20*sin(2*pi*(1:120)/12), frequency=12)
fit1 <- tslm(y ~ trend + season)
fit2 <- tslm(y ~ season)
CV(fit1)
CV(fit2)
\end{verbatim}
**CVar**

k-fold Cross-Validation applied to an autoregressive model

**Description**

CVar computes the errors obtained by applying an autoregressive modelling function to subsets of the time series $y$ using k-fold cross-validation as described in Bergmeir, Hyndman and Koo (2015). It also applies a Ljung-Box test to the residuals. If this test is significant (see returned pvalue), there is serial correlation in the residuals and the model can be considered to be underfitting the data. In this case, the cross-validated errors can underestimate the generalization error and should not be used.

**Usage**

```r
CVar(
  y,
  k = 10,
  FUN = nnetar,
  cvtrace = FALSE,
  blocked = FALSE,
  LBlags = 24,
  ...)
```

**Arguments**

- **y**: Univariate time series
- **k**: Number of folds to use for cross-validation.
- **FUN**: Function to fit an autoregressive model. Currently, it only works with the `nnetar` function.
- **cvtrace**: Provide progress information.
- **blocked**: choose folds randomly or as blocks?
- **LBlags**: lags for the Ljung-Box test, defaults to 24, for yearly series can be set to 20
- **...**: Other arguments are passed to `FUN`.

**Value**

A list containing information about the model and accuracy for each fold, plus other summary information computed across folds.

**Author(s)**

Gabriel Caceres and Rob J Hyndman
References


See Also

`CV, tsCV`.

Examples

```r
modelcv <- CVar(lynx, k=5, lambda=0.15)
print(modelcv)
print(modelcv$fold1)

library(ggplot2)
autoplot(lynx, series="Data") +
  autolayer(modelcv$testfit, series="Fits") +
  autolayer(modelcv$residuals, series="Residuals")
ggAcf(modelcv$residuals)
```

dm.test

**Diebold-Mariano test for predictive accuracy**

Description

The Diebold-Mariano test compares the forecast accuracy of two forecast methods.

Usage

```r
dm.test(
  e1,
  e2,
  alternative = c("two.sided", "less", "greater"),
  h = 1,
  power = 2
)
```

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>e1</code></td>
<td>Forecast errors from method 1.</td>
</tr>
<tr>
<td><code>e2</code></td>
<td>Forecast errors from method 2.</td>
</tr>
<tr>
<td><code>alternative</code></td>
<td>a character string specifying the alternative hypothesis, must be one of &quot;two.sided&quot; (default), &quot;greater&quot; or &quot;less&quot;. You can specify just the initial letter.</td>
</tr>
<tr>
<td><code>h</code></td>
<td>The forecast horizon used in calculating e1 and e2.</td>
</tr>
<tr>
<td><code>power</code></td>
<td>The power used in the loss function. Usually 1 or 2.</td>
</tr>
</tbody>
</table>
This function implements the modified test proposed by Harvey, Leybourne and Newbold (1997). The null hypothesis is that the two methods have the same forecast accuracy. For alternative="less", the alternative hypothesis is that method 2 is less accurate than method 1. For alternative="greater", the alternative hypothesis is that method 2 is more accurate than method 1. For alternative="two.sided", the alternative hypothesis is that method 1 and method 2 have different levels of accuracy.

A list with class "htest" containing the following components:

**statistic** the value of the DM-statistic.

**parameter** the forecast horizon and loss function power used in the test.

**alternative** a character string describing the alternative hypothesis.

**p.value** the p-value for the test.

**method** a character string with the value "Diebold-Mariano Test".

**data.name** a character vector giving the names of the two error series.

George Athanasopoulos


```r
# Test on in-sample one-step forecasts
f1 <- ets(WWWusage)
f2 <- auto.arima(WWWusage)
accuracy(f1)
accuracy(f2)
dm.test(residuals(f1),residuals(f2),h=1)

# Test on out-of-sample one-step forecasts
f1 <- ets(WWWusage[1:80])
f2 <- auto.arima(WWWusage[1:80])
f1.out <- ets(WWWusage[81:100],model=f1)
f2.out <- Arima(WWWusage[81:100],model=f2)
accuracy(f1.out)
accuracy(f2.out)
dm.test(residuals(f1.out),residuals(f2.out),h=1)
```
Description


Usage

dshw(
  y,
  period1 = NULL,
  period2 = NULL,
  h = 2 * max(period1, period2),
  alpha = NULL,
  beta = NULL,
  gamma = NULL,
  omega = NULL,
  phi = NULL,
  lambda = NULL,
  biasadj = FALSE,
  armethod = TRUE,
  model = NULL
)

Arguments

y Either an msts object with two seasonal periods or a numeric vector.
period1 Period of the shorter seasonal period. Only used if y is not an msts object.
period2 Period of the longer seasonal period. Only used if y is not an msts object.
h Number of periods for forecasting.
alpha Smoothing parameter for the level. If NULL, the parameter is estimated using least squares.
beta Smoothing parameter for the slope. If NULL, the parameter is estimated using least squares.
gamma Smoothing parameter for the first seasonal period. If NULL, the parameter is estimated using least squares.
omega Smoothing parameter for the second seasonal period. If NULL, the parameter is estimated using least squares.
phi Autoregressive parameter. If NULL, the parameter is estimated using least squares.
lambda Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
biasadj
Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

armethod
If TRUE, the forecasts are adjusted using an AR(1) model for the errors.

model
If it’s specified, an existing model is applied to a new data set.

Details
Taylor’s (2003) double-seasonal Holt-Winters method uses additive trend and multiplicative seasonality, where there are two seasonal components which are multiplied together. For example, with a series of half-hourly data, one would set period1=48 for the daily period and period2=336 for the weekly period. The smoothing parameter notation used here is different from that in Taylor (2003); instead it matches that used in Hyndman et al (2008) and that used for the ets function.

Value
An object of class "forecast" which is a list that includes the following elements:

model
A list containing information about the fitted model

method
The name of the forecasting method as a character string

mean
Point forecasts as a time series

x
The original time series.

residuals
Residuals from the fitted model. That is x minus fitted values.

fitted
Fitted values (one-step forecasts)

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by dshw.

Author(s)
Rob J Hyndman

References


See Also
HoltWinters.ets.
**Examples**

```r
## Not run:
fcast <- dshw(taylor)
plot(fcast)

t <- seq(0,5,by=1/20)
x <- exp(sin(2*pi*t) + cos(2*pi*t*4) + rnorm(length(t),0,.1))
fit <- dshw(x,20,5)
plot(fit)

## End(Not run)
```

---

**easter**

*Easter holidays in each season*

**Description**

Returns a vector of 0’s and 1’s or fractional results if Easter spans March and April in the observed time period. Easter is defined as the days from Good Friday to Easter Sunday inclusively, plus optionally Easter Monday if `easter.mon=TRUE`.

**Usage**

`easter(x, easter.mon = FALSE)`

**Arguments**

- `x` Monthly or quarterly time series
- `easter.mon` If TRUE, the length of Easter holidays includes Easter Monday.

**Details**

Useful for adjusting calendar effects.

**Value**

Time series

**Author(s)**

Earo Wang

**Examples**

`easter(wineind, easter.mon = TRUE)`
ets

Exponential smoothing state space model

Description

Returns ets model applied to y.

Usage

ets(
  y,
  model = "ZZZ",
  damped = NULL,
  alpha = NULL,
  beta = NULL,
  gamma = NULL,
  phi = NULL,
  additive.only = FALSE,
  lambda = NULL,
  biasadj = FALSE,
  lower = c(rep(1e-04, 3), 0.8),
  upper = c(rep(0.9999, 3), 0.98),
  opt.crit = c("lik", "amse", "mse", "sigma", "mae"),
  nmse = 3,
  bounds = c("both", "usual", "admissible"),
  ic = c("aicc", "aic", "bic"),
  restrict = TRUE,
  allow.multiplicative.trend = FALSE,
  use.initial.values = FALSE,
  na.action = c("na.contiguous", "na.interp", "na.fail"),
  ...
)

Arguments

y a numeric vector or time series of class ts
model Usually a three-character string identifying method using the framework terminology of Hyndman et al. (2002) and Hyndman et al. (2008). The first letter denotes the error type ("A", "M" or "Z"); the second letter denotes the trend type ("N", "A", "M" or "Z"); and the third letter denotes the season type ("N", "A", "M" or "Z"). In all cases, "N"=none, "A"=additive, "M"=multiplicative and "Z"=automatically selected. So, for example, "ANN" is simple exponential smoothing with additive errors, "MAM" is multiplicative Holt-Winters' method with multiplicative errors, and so on.

It is also possible for the model to be of class "ets", and equal to the output from a previous call to ets. In this case, the same model is fitted to y without
re-estimating any smoothing parameters. See also the `use.initial.values` argument.

damped If TRUE, use a damped trend (either additive or multiplicative). If NULL, both damped and non-damped trends will be tried and the best model (according to the information criterion `ic`) returned.

alpha Value of alpha. If NULL, it is estimated.

beta Value of beta. If NULL, it is estimated.

gamma Value of gamma. If NULL, it is estimated.

phi Value of phi. If NULL, it is estimated.

additive.only If TRUE, will only consider additive models. Default is FALSE.

lambda Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated. When `lambda` is specified, `additive.only` is set to TRUE.

biasadj Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If `biasadj` is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

lower Lower bounds for the parameters (alpha, beta, gamma, phi)

upper Upper bounds for the parameters (alpha, beta, gamma, phi)

opt.crit Optimization criterion. One of "mse" (Mean Square Error), "amse" (Average MSE over first `nmse` forecast horizons), "sigma" (Standard deviation of residuals), "mae" (Mean of absolute residuals), or "lik" (Log-likelihood, the default).

nmse Number of steps for average multistep MSE (1<=`nmse`<=30).

bounds Type of parameter space to impose: "usual" indicates all parameters must lie between specified lower and upper bounds; "admissible" indicates parameters must lie in the admissible space; "both" (default) takes the intersection of these regions.

ic Information criterion to be used in model selection.

restrict If TRUE (default), the models with infinite variance will not be allowed.

allow.multiplicative.trend If TRUE, models with multiplicative trend are allowed when searching for a model. Otherwise, the model space excludes them. This argument is ignored if a multiplicative trend model is explicitly requested (e.g., using model="MMN").

use.initial.values If TRUE and model is of class "ets", then the initial values in the model are also not re-estimated.

na.action A function which indicates what should happen when the data contains NA values. By default, the largest contiguous portion of the time-series will be used.

... Other undocumented arguments.
Details

Based on the classification of methods as described in Hyndman et al (2008).

The methodology is fully automatic. The only required argument for ets is the time series. The model is chosen automatically if not specified. This methodology performed extremely well on the M3-competition data. (See Hyndman, et al, 2002, below.)

Value

An object of class "ets".

The generic accessor functions fitted.values and residuals extract useful features of the value returned by ets and associated functions.

Author(s)

Rob J Hyndman

References


See Also

HoltWinters, rrw, Arima.

Examples

fit <- ets(USAccDeaths)
plot(forecast(fit))

findfrequency  Find dominant frequency of a time series

Description

findfrequency returns the period of the dominant frequency of a time series. For seasonal data, it will return the seasonal period. For cyclic data, it will return the average cycle length.
Usage

findfrequency(x)

Arguments

x

a numeric vector or time series of class ts

Details

The dominant frequency is determined from a spectral analysis of the time series. First, a linear
trend is removed, then the spectral density function is estimated from the best fitting autoregressive
model (based on the AIC). If there is a large (possibly local) maximum in the spectral density
function at frequency $f$, then the function will return the period $1/f$ (rounded to the nearest integer).
If no such dominant frequency can be found, the function will return 1.

Value

an integer value

Author(s)

Rob J Hyndman

Examples

findfrequency(USAccDeaths) # Monthly data
findfrequency(taylor) # Half-hourly data
findfrequency(lynx) # Annual data

fitted.ARFIMA

h-step in-sample forecasts for time series models.

Description

Returns h-step forecasts for the data used in fitting the model.

Usage

## S3 method for class 'ARIMA'
fitted(object, h = 1, ...)

## S3 method for class 'Arima'
fitted(object, h = 1, ...)

## S3 method for class 'ar'
fitted(object, ...)
fitted.ARIMA

## S3 method for class 'bats'
fitted(object, h = 1, ...)

## S3 method for class 'ets'
fitted(object, h = 1, ...)

## S3 method for class 'modelAR'
fitted(object, h = 1, ...)

## S3 method for class 'nnetar'
fitted(object, h = 1, ...)

## S3 method for class 'tbats'
fitted(object, h = 1, ...)

Arguments

object An object of class "Arima", "bats", "tbats", "ets" or "nnetar".

h The number of steps to forecast ahead.

... Other arguments.

Value

A time series of the h-step forecasts.

Author(s)

Rob J Hyndman & Mitchell O'Hara-Wild

See Also


Examples

fit <- ets(WWWusage)
plot(WWWusage)
lines(fitted(fit), col='red')
lines(fitted(fit, h=2), col='green')
lines(fitted(fit, h=3), col='blue')
legend("topleft", legend=paste("h =",1:3), col=2:4, lty=1)
Description

forecast is a generic function for forecasting from time series or time series models. The function invokes particular methods which depend on the class of the first argument.

Usage

```
forecast(object, ...)  
## Default S3 method: 
forecast(object, ...)  
## S3 method for class 'ts' 
forecast(
  object,
  h = ifelse(frequency(object) > 1, 2 * frequency(object), 10),
  level = c(80, 95),
  fan = FALSE,
  robust = FALSE,
  lambda = NULL,
  biasadj = FALSE,
  find.frequency = FALSE,
  allow.multiplicative.trend = FALSE,
  model = NULL,
  ...
)
```

Arguments

- `object`: a time series or time series model for which forecasts are required
- `...`: Additional arguments affecting the forecasts produced. If `model=NULL`, `forecast.ts` passes these to `ets` or `stlf` depending on the frequency of the time series. If `model` is not `NULL`, the arguments are passed to the relevant modelling function.
- `h`: Number of periods for forecasting
- `level`: Confidence level for prediction intervals.
- `fan`: If `TRUE`, `level` is set to `seq(51, 99, by=3)`. This is suitable for fan plots.
- `robust`: If `TRUE`, the function is robust to missing values and outliers in `object`. This argument is only valid when `object` is of class `ts`.
- `lambda`: Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if `NULL`. Otherwise, data transformed before model is estimated.
biasadj
Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

find.frequency
If TRUE, the function determines the appropriate period, if the data is of unknown period.

allow.multiplicative.trend
If TRUE, then ETS models with multiplicative trends are allowed. Otherwise, only additive or no trend ETS models are permitted.

model
An object describing a time series model; e.g., one of class ets, Arima, bats, tbats, or nnetar.

Details
For example, the function forecast.Arima makes forecasts based on the results produced by arima.

If model=NULL, the function forecast.ts makes forecasts using ets models (if the data are non-seasonal or the seasonal period is 12 or less) or stlf (if the seasonal period is 13 or more).

If model is not NULL, forecast.ts will apply the model to the object time series, and then generate forecasts accordingly.

Value
An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

The generic accessor functions fitted.values and residuals extract various useful features of the value returned by forecast$model.

An object of class "forecast" is a list usually containing at least the following elements:

model
A list containing information about the fitted model

method
The name of the forecasting method as a character string

mean
Point forecasts as a time series

lower
Lower limits for prediction intervals

upper
Upper limits for prediction intervals

level
The confidence values associated with the prediction intervals

x
The original time series (either object itself or the time series used to create the model stored as object).

residuals
Residuals from the fitted model. For models with additive errors, the residuals will be x minus the fitted values.

fitted
Fitted values (one-step forecasts)

Author(s)
Rob J Hyndman
See Also

Other functions which return objects of class "forecast" are forecast.ets, forecast.Arima, forecast.HoltWinters, forecast.StructTS, meanf, rwf, splinef, thetaf, croston, ses, holt, hw.

Examples

WWWusage %>% forecast %>% plot
fit <- ets(window(WWWusage, end=60))
fc <- forecast(WWWusage, model=fit)
Value

An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

An object of class "forecast" is a list containing at least the following elements:

- **model**: A list containing information about the fitted model
- **method**: The name of the forecasting method as a character string
- **mean**: Point forecasts as a time series
- **lower**: Lower limits for prediction intervals
- **upper**: Upper limits for prediction intervals
- **level**: The confidence values associated with the prediction intervals
- **x**: The original time series (either object itself or the time series used to create the model stored as object).
- **xreg**: The external regressors used in fitting (if given).
- **residuals**: Residuals from the fitted model. That is x minus fitted values.
- **fitted**: Fitted values (one-step forecasts)

Author(s)

Christoph Bergmeir, Fotios Petropoulos

References


See Also

- baggedModel

Examples

```r
fit <- baggedModel(WWWusage)
fcast <- forecast(fit)
plot(fcast)

## Not run:
fit2 <- baggedModel(WWWusage, fn="auto.arima")
fcast2 <- forecast(fit2)
plot(fcast2)
accuracy(fcast2)
## End(Not run)
```
**Description**

Forecasts $h$ steps ahead with a BATS model. Prediction intervals are also produced.

**Usage**

```r
## S3 method for class 'bats'
forecast(object, h, level = c(80, 95), fan = FALSE, biasadj = NULL, ...)

## S3 method for class 'tbats'
forecast(object, h, level = c(80, 95), fan = FALSE, biasadj = NULL, ...)
```

**Arguments**

- `object` An object of class "bats". Usually the result of a call to `bats`.
- `h` Number of periods for forecasting. Default value is twice the largest seasonal period (for seasonal data) or ten (for non-seasonal data).
- `level` Confidence level for prediction intervals.
- `fan` If TRUE, level is set to `seq(51, 99, by=3)`. This is suitable for fan plots.
- `biasadj` Use adjusted back-transformed mean for Box-Cox transformations. If TRUE, point forecasts and fitted values are mean forecast. Otherwise, these points can be considered the median of the forecast densities.
- `...` Other arguments, currently ignored.

**Value**

An object of class "forecast".

The function `summary` is used to obtain and print a summary of the results, while the function `plot` produces a plot of the forecasts and prediction intervals.

The generic accessor functions `fitted.values` and `residuals` extract useful features of the value returned by `forecast.bats`.

An object of class "forecast" is a list containing at least the following elements:

- `model` A copy of the bats object
- `method` The name of the forecasting method as a character string
- `mean` Point forecasts as a time series
- `lower` Lower limits for prediction intervals
- `upper` Upper limits for prediction intervals
- `level` The confidence values associated with the prediction intervals
forecast.ets

The original time series (either object itself or the time series used to create the model stored as object).

residuals Residuals from the fitted model.

fitted Fitted values (one-step forecasts)

Author(s)

Slava Razbash and Rob J Hyndman

References


See Also

bats, tbats, forecast.ets.

Examples

## Not run:
fit <- bats(USAccDeaths)
plot(forecast(fit))
taylor.fit <- bats(taylor)
plot(forecast(taylor.fit))
## End(Not run)

---

forecast.ets Forecasting using ETS models

Description

Returns forecasts and other information for univariate ETS models.

Usage

## S3 method for class 'ets'
forecast(
  object,
  h = ifelse(object$m > 1, 2 * object$m, 10),
  level = c(80, 95),
  fan = FALSE,
  simulate = FALSE,


```r
bootstrap = FALSE,
npaths = 5000,
PI = TRUE,
lambda = object$lambda,
biasadj = NULL,
...
)
```

**Arguments**

- **object**: An object of class "ets". Usually the result of a call to `ets`.
- **h**: Number of periods for forecasting
- **level**: Confidence level for prediction intervals.
- **fan**: If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.
- **simulate**: If TRUE, prediction intervals are produced by simulation rather than using analytic formulae. Errors are assumed to be normally distributed.
- **bootstrap**: If TRUE, then prediction intervals are produced by simulation using resampled errors (rather than normally distributed errors).
- **npaths**: Number of sample paths used in computing simulated prediction intervals.
- **PI**: If TRUE, prediction intervals are produced, otherwise only point forecasts are calculated. If PI is FALSE, then level, fan, simulate, bootstrap and npaths are all ignored.
- **lambda**: Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
- **biasadj**: Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.
- **...**: Other arguments.

**Value**

An object of class "forecast".

The function `summary` is used to obtain and print a summary of the results, while the function `plot` produces a plot of the forecasts and prediction intervals.

The generic accessor functions `fitted.values` and `residuals` extract useful features of the value returned by `forecast.ets`.

An object of class "forecast" is a list containing at least the following elements:

- **model**: A list containing information about the fitted model
- **method**: The name of the forecasting method as a character string
- **mean**: Point forecasts as a time series
- **lower**: Lower limits for prediction intervals
upper Upper limits for prediction intervals
level The confidence values associated with the prediction intervals
x The original time series (either object itself or the time series used to create the model stored as object).
residuals Residuals from the fitted model. For models with additive errors, the residuals are x - fitted values. For models with multiplicative errors, the residuals are equal to x/(fitted values) - 1.
fitted Fitted values (one-step forecasts)

Author(s)
Rob J Hyndman

See Also
ets, ses, holt, hw.

Examples
fit <- ets(USAccDeaths)
plot(forecast(fit,h=48))

forecast.fracdiff

Forecasting using ARIMA or ARFIMA models

Description
Returns forecasts and other information for univariate ARIMA models.

Usage
## S3 method for class 'fracdiff'
forecast(
  object,
  h = 10,
  level = c(80, 95),
  fan = FALSE,
  lambda = object$lambda,
  biasadj = NULL,
  ...
)

## S3 method for class 'Arima'
forecast(
  object,
  h = ifelse(object$arma[5] > 1, 2 * object$arma[5], 10),
  ...
level = c(80, 95),
fan = FALSE,
xreg = NULL,
lambda = object$lambda,
bootstrap = FALSE,
npaths = 5000,
biasadj = NULL,
...
)

## S3 method for class 'ar'
forecast(
  object,
  h = 10,
  level = c(80, 95),
  fan = FALSE,
  lambda = NULL,
  bootstrap = FALSE,
  npaths = 5000,
  biasadj = FALSE,
  ...
)

Arguments

- **object**: An object of class "Arima", "ar" or "fracdiff". Usually the result of a call to `arima`, `auto.arima`, `ar`, `arfima` or `fracdiff`.
- **h**: Number of periods for forecasting. If `xreg` is used, `h` is ignored and the number of forecast periods is set to the number of rows of `xreg`.
- **level**: Confidence level for prediction intervals.
- **fan**: If `TRUE`, level is set to `seq(51, 99, by=3)`. This is suitable for fan plots.
- **lambda**: Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if `NULL`. Otherwise, data transformed before model is estimated.
- **biasadj**: Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If `biasadj` is `TRUE`, an adjustment will be made to produce mean forecasts and fitted values.
- **...**: Other arguments.
- **xreg**: Future values of an regression variables (for class `Arima` objects only). A numerical vector or matrix of external regressors; it should not be a data frame.
- **bootstrap**: If `TRUE`, then prediction intervals computed using simulation with resampled errors.
- **npaths**: Number of sample paths used in computing simulated prediction intervals when `bootstrap=TRUE`. 
Details

For Arima or ar objects, the function calls `predict.Arima` or `predict.ar` and constructs an object of class "forecast" from the results. For fracdiff objects, the calculations are all done within `forecast.fracdiff` using the equations given by Peiris and Perera (1988).

Value

An object of class "forecast".

The function `summary` is used to obtain and print a summary of the results, while the function `plot` produces a plot of the forecasts and prediction intervals.

The generic accessor functions `fitted.values` and `residuals` extract useful features of the value returned by `forecast.Arima`.

An object of class "forecast" is a list containing at least the following elements:

- model: A list containing information about the fitted model
- method: The name of the forecasting method as a character string
- mean: Point forecasts as a time series
- lower: Lower limits for prediction intervals
- upper: Upper limits for prediction intervals
- level: The confidence values associated with the prediction intervals
- x: The original time series (either object itself or the time series used to create the model stored as object).
- residuals: Residuals from the fitted model. That is x minus fitted values.
- fitted: Fitted values (one-step forecasts)

Author(s)

Rob J Hyndman

References


See Also

`predict.Arima`, `predict.ar`, `auto.arima`, `Arima`, `arima`, `ar`, `arfima`.

Examples

```r
fit <- Arima(WWWusage,c(3,1,0))
plot(forecast(fit))

library(fracdiff)
x <- fracdiff.sim(100, ma=-.4, d=.3)$series
fit <- arfima(x)
plot(forecast(fit,h=30))
```
forecast.HoltWinters  Forecasting using Holt-Winters objects

Description
Returns forecasts and other information for univariate Holt-Winters time series models.

Usage
```r
## S3 method for class 'HoltWinters'
forecast(
  object,
  h = ifelse(frequency(object$x) > 1, 2 * frequency(object$x), 10),
  level = c(80, 95),
  fan = FALSE,
  lambda = NULL,
  biasadj = NULL,
  ...
)
```

Arguments
- **object**: An object of class "HoltWinters". Usually the result of a call to `HoltWinters`
- **h**: Number of periods for forecasting
- **level**: Confidence level for prediction intervals.
- **fan**: If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.
- **lambda**: Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
- **biasadj**: Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.
- **...**: Other arguments.

Details
This function calls `predict.HoltWinters` and constructs an object of class "forecast" from the results.

It is included for completeness, but the `ets` is recommended for use instead of `HoltWinters`.
Value

An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by forecast.HoltWinters.

An object of class "forecast" is a list containing at least the following elements:

- model: A list containing information about the fitted model
- method: The name of the forecasting method as a character string
- mean: Point forecasts as a time series
- lower: Lower limits for prediction intervals
- upper: Upper limits for prediction intervals
- level: The confidence values associated with the prediction intervals
- x: The original time series (either object itself or the time series used to create the model stored as object).
- residuals: Residuals from the fitted model.
- fitted: Fitted values (one-step forecasts)

Author(s)

Rob J Hyndman

See Also


Examples

```R
fit <- HoltWinters(WWWusage, gamma=FALSE)
plot(forecast(fit))
```

forecast.lm

Forecast a linear model with possible time series components

Description

forecast.lm is used to predict linear models, especially those involving trend and seasonality components.
Usage

```r
## S3 method for class 'lm'
forecast(
  object,
  newdata,
  h = 10,
  level = c(80, 95),
  fan = FALSE,
  lambda = object$lambda,
  biasadj = NULL,
  ts = TRUE,
  ...
)
```

Arguments

- **object**: Object of class "lm", usually the result of a call to `lm` or `tslm`.
- **newdata**: An optional data frame in which to look for variables with which to predict. If omitted, it is assumed that the only variables are trend and season, and h forecasts are produced.
- **h**: Number of periods for forecasting. Ignored if `newdata` present.
- **level**: Confidence level for prediction intervals.
- **fan**: If TRUE, level is set to `seq(51,99,by=3)`. This is suitable for fan plots.
- **lambda**: Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
- **biasadj**: Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.
- **ts**: If TRUE, the forecasts will be treated as time series provided the original data is a time series; the `newdata` will be interpreted as related to the subsequent time periods. If FALSE, any time series attributes of the original data will be ignored.
- **...**: Other arguments passed to `predict.lm()`.

Details

`forecast.lm` is largely a wrapper for `predict.lm()` except that it allows variables "trend" and "season" which are created on the fly from the time series characteristics of the data. Also, the output is reformatted into a `forecast` object.

Value

- An object of class "forecast".

The function `summary` is used to obtain and print a summary of the results, while the function `plot` produces a plot of the forecasts and prediction intervals.
The generic accessor functions `fitted.values` and `residuals` extract useful features of the value returned by `forecast.lm`.

An object of class "forecast" is a list containing at least the following elements:

- `model`: A list containing information about the fitted model
- `method`: The name of the forecasting method as a character string
- `mean`: Point forecasts as a time series
- `lower`: Lower limits for prediction intervals
- `upper`: Upper limits for prediction intervals
- `level`: The confidence values associated with the prediction intervals
- `x`: The historical data for the response variable.
- `residuals`: Residuals from the fitted model. That is x minus fitted values.
- `fitted`: Fitted values

**Author(s)**

Rob J Hyndman

**See Also**

tslm, lm.

**Examples**

```r
y <- ts(rnorm(120,0,3) + 1:120 + 20*sin(2*pi*(1:120)/12), frequency=12)
fit <- tslm(y ~ trend + season)
plot(forecast(fit, h=20))
```

**forecast.mlm**

*Forecast a multiple linear model with possible time series components*

**Description**

`forecast.mlm` is used to predict multiple linear models, especially those involving trend and seasonality components.
Usage

```r
## S3 method for class 'mlm'
forecast(
  object,
  newdata,
  h = 10,
  level = c(80, 95),
  fan = FALSE,
  lambda = object$lambda,
  biasadj = NULL,
  ts = TRUE,
  ...
)
```

Arguments

- `object`: Object of class "mlm", usually the result of a call to `lm` or `tslm`.
- `newdata`: An optional data frame in which to look for variables with which to predict. If omitted, it is assumed that the only variables are trend and season, and `h` forecasts are produced.
- `h`: Number of periods for forecasting. Ignored if `newdata` present.
- `level`: Confidence level for prediction intervals.
- `fan`: If `TRUE`, level is set to `seq(51,99,by=3)`. This is suitable for fan plots.
- `lambda`: Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if `NULL`. Otherwise, data transformed before model is estimated.
- `biasadj`: Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If `biasadj` is `TRUE`, an adjustment will be made to produce mean forecasts and fitted values.
- `ts`: If `TRUE`, the forecasts will be treated as time series provided the original data is a time series; the `newdata` will be interpreted as related to the subsequent time periods. If `FALSE`, any time series attributes of the original data will be ignored.
- `...`: Other arguments passed to `forecast.lm()`.

Details

`forecast.mlm` is largely a wrapper for `forecast.lm()` except that it allows forecasts to be generated on multiple series. Also, the output is reformatted into a `mforecast` object.

Value

An object of class "mforecast".

The function `summary` is used to obtain and print a summary of the results, while the function `plot` produces a plot of the forecasts and prediction intervals.
The generic accessor functions `fitted.values` and `residuals` extract useful features of the value returned by `forecast.lm`.

An object of class "mforecast" is a list containing at least the following elements:

- **model**: A list containing information about the fitted model
- **method**: The name of the forecasting method as a character string
- **mean**: Point forecasts as a multivariate time series
- **lower**: Lower limits for prediction intervals of each series
- **upper**: Upper limits for prediction intervals of each series
- **level**: The confidence values associated with the prediction intervals
- **x**: The historical data for the response variable.
- **residuals**: Residuals from the fitted model. That is x minus fitted values.
- **fitted**: Fitted values

**Author(s)**

Mitchell O’Hara-Wild

**See Also**

`t Belmont, forecast.lm, lm`

**Examples**

```r
lungDeaths <- cbind(mdeaths, fdeaths)
fit <- tslm(lungDeaths ~ trend + season)
fcast <- forecast(fit, h=10)

carPower <- as.matrix(mtcars[,c("qsec","hp")])
carmpg <- mtcars[,"mpg"]
fit <- lm(carPower ~ carmpg)
fcast <- forecast(fit, newdata=data.frame(carmpg=30))
```

**Description**

Returns forecasts and other information for user-defined models.
Usage
## S3 method for class 'modelAR'
forecast(
  object,
  h = ifelse(object$m > 1, 2 * object$m, 10),
  PI = FALSE,
  level = c(80, 95),
  fan = FALSE,
  xreg = NULL,
  lambda = object$lambda,
  bootstrap = FALSE,
  npaths = 1000,
  innov = NULL,
  ...
)

Arguments

- **object**: An object of class "modelAR" resulting from a call to `modelAR`.
- **h**: Number of periods for forecasting. If `xreg` is used, `h` is ignored and the number of forecast periods is set to the number of rows of `xreg`.
- **PI**: If `TRUE`, prediction intervals are produced, otherwise only point forecasts are calculated. If `PI` is `FALSE`, then `level`, `fan`, `bootstrap` and `npaths` are all ignored.
- **level**: Confidence level for prediction intervals.
- **fan**: If `TRUE`, `level` is set to `seq(51, 99, by=3)`. This is suitable for fan plots.
- **xreg**: Future values of external regressor variables.
- **lambda**: Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if `NULL`. Otherwise, data transformed before model is estimated.
- **bootstrap**: If `TRUE`, then prediction intervals computed using simulations with resampled residuals rather than normally distributed errors. Ignored if `innov` is not `NULL`.
- **npaths**: Number of sample paths used in computing simulated prediction intervals.
- **innov**: Values to use as innovations for prediction intervals. Must be a matrix with `h` rows and `npaths` columns (vectors are coerced into a matrix). If present, `bootstrap` is ignored.
- **...**: Additional arguments passed to `simulate.nnetar`

Details

Prediction intervals are calculated through simulations and can be slow. Note that if the model is too complex and overfits the data, the residuals can be arbitrarily small; if used for prediction interval calculations, they could lead to misleadingly small values.
Value

An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by forecast.nnetar.

An object of class "forecast" is a list containing at least the following elements:

- model: A list containing information about the fitted model.
- method: The name of the forecasting method as a character string.
- mean: Point forecasts as a time series.
- lower: Lower limits for prediction intervals.
- upper: Upper limits for prediction intervals.
- level: The confidence values associated with the prediction intervals.
- x: The original time series (either object itself or the time series used to create the model stored as object).
- xreg: The external regressors used in fitting (if given).
- residuals: Residuals from the fitted model. That is x minus fitted values.
- fitted: Fitted values (one-step forecasts).
- ...: Other arguments.

Author(s)

Rob J Hyndman and Gabriel Caceres

See Also

mnetar.

Description

mforecast is a class of objects for forecasting from multivariate time series or multivariate time series models. The function invokes particular methods which depend on the class of the first argument.
Usage

```r
## S3 method for class 'mts'
forecast(
  object,
  h = ifelse(frequency(object) > 1, 2 * frequency(object), 10),
  level = c(80, 95),
  fan = FALSE,
  robust = FALSE,
  lambda = NULL,
  biasadj = FALSE,
  find.frequency = FALSE,
  allow.multiplicative.trend = FALSE,
  ...
)
```

Arguments

- `object` a multivariate time series or multivariate time series model for which forecasts are required
- `h` Number of periods for forecasting
- `level` Confidence level for prediction intervals.
- `fan` If TRUE, level is set to `seq(51, 99, by=3)`. This is suitable for fan plots.
- `robust` If TRUE, the function is robust to missing values and outliers in `object`. This argument is only valid when `object` is of class `mts`.
- `lambda` Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if `NULL`. Otherwise, data transformed before model is estimated.
- `biasadj` Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If `biasadj` is TRUE, an adjustment will be made to produce mean forecasts and fitted values.
- `find.frequency` If TRUE, the function determines the appropriate period, if the data is of unknown period.
- `allow.multiplicative.trend` If TRUE, then ETS models with multiplicative trends are allowed. Otherwise, only additive or no trend ETS models are permitted.
- `...` Additional arguments affecting the forecasts produced.

Details

For example, the function `forecast.mlm` makes multivariate forecasts based on the results produced by `tslm.`
Value

An object of class "mforecast".

The function `summary` is used to obtain and print a summary of the results, while the function `plot` produces a plot of the multivariate forecasts and prediction intervals.

The generic accessors functions `fitted.values` and `residuals` extract various useful features of the value returned by `forecast$model`.

An object of class "mforecast" is a list usually containing at least the following elements:

- `model` A list containing information about the fitted model
- `method` The name of the forecasting method as a character string
- `mean` Point forecasts as a time series
- `lower` Lower limits for prediction intervals
- `upper` Upper limits for prediction intervals
- `level` The confidence values associated with the prediction intervals
- `x` The original time series (either `object` itself or the time series used to create the model stored as `object`).
- `residuals` Residuals from the fitted model. For models with additive errors, the residuals will be `x` minus the fitted values.
- `fitted` Fitted values (one-step forecasts)

Author(s)

Rob J Hyndman & Mitchell O'Hara-Wild

See Also

Other functions which return objects of class "mforecast" are `forecast.mlm`, `forecast.varest`.

---

forecast.nnetar  
Forecasting using neural network models

Description

Returns forecasts and other information for univariate neural network models.

Usage

```r
## S3 method for class 'nnetar'
forecast(
  object,
  h = ifelse(object$m > 1, 2 * object$m, 10),
  PI = FALSE,
  level = c(80, 95),
  fan = FALSE,
)```

Arguments

object | An object of class "nnetar" resulting from a call to nnetar.

h | Number of periods for forecasting. If xreg is used, h is ignored and the number of forecast periods is set to the number of rows of xreg.

PI | If TRUE, prediction intervals are produced, otherwise only point forecasts are calculated. If PI is FALSE, then level, fan, bootstrap and npaths are all ignored.

level | Confidence level for prediction intervals.

fan | If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.

xreg | Future values of external regressor variables.

lambda | Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.

bootstrap | If TRUE, then prediction intervals computed using simulations with resampled residuals rather than normally distributed errors. Ignored if innov is not NULL.

npaths | Number of sample paths used in computing simulated prediction intervals.

innov | Values to use as innovations for prediction intervals. Must be a matrix with h rows and npaths columns (vectors are coerced into a matrix). If present, bootstrap is ignored.

... | Additional arguments passed to simulate.nnetar

Details

Prediction intervals are calculated through simulations and can be slow. Note that if the network is too complex and overfits the data, the residuals can be arbitrarily small; if used for prediction interval calculations, they could lead to misleadingly small values. It is possible to use out-of-sample residuals to ameliorate this, see examples.

Value

An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by forecast.nnetar.

An object of class "forecast" is a list containing at least the following elements:
model A list containing information about the fitted model
method The name of the forecasting method as a character string
mean Point forecasts as a time series
lower Lower limits for prediction intervals
upper Upper limits for prediction intervals
level The confidence values associated with the prediction intervals
x The original time series (either object itself or the time series used to create the model stored as object).
xreg The external regressors used in fitting (if given).
residuals Residuals from the fitted model. That is x minus fitted values.
fitted Fitted values (one-step forecasts)
... Other arguments

Author(s)
Rob J Hyndman and Gabriel Caceres

See Also
nnetar.

Examples

## Fit & forecast model
fit <- nnetar(USAccDeaths, size=2)
fcast <- forecast(fit, h=20)
plot(fcast)

## Not run:
## Include prediction intervals in forecast
fcast2 <- forecast(fit, h=20, PI=TRUE, npaths=100)
plot(fcast2)

## Set up out-of-sample innovations using cross-validation
fit_cv <- CVar(USAccDeaths, size=2)
res_sd <- sd(fit_cv$residuals, na.rm=TRUE)
myinnovs <- rnorm(20*100, mean=0, sd=res_sd)
## Forecast using new innovations
fcast3 <- forecast(fit, h=20, PI=TRUE, npaths=100, innov=myinnovs)
plot(fcast3)

## End(Not run)
**Description**

Forecasts of STL objects are obtained by applying a non-seasonal forecasting method to the seasonally adjusted data and re-seasonalizing using the last year of the seasonal component.

**Usage**

```r
## S3 method for class 'stl'
forecast(
  object,
  method = c("ets", "arima", "naive", "rwdrift"),
  etsmodel = "ZZN",
  forecastfunction = NULL,
  h = frequency(object$time.series) * 2,
  level = c(80, 95),
  fan = FALSE,
  lambda = NULL,
  biasadj = NULL,
  xreg = NULL,
  newxreg = NULL,
  allow.multiplicative.trend = FALSE,
  ...
)
```

```r
stlm(
  y,
  s.window = 7 + 4 * seq(6),
  robust = FALSE,
  method = c("ets", "arima"),
  modelfunction = NULL,
  model = NULL,
  etsmodel = "ZZN",
  lambda = NULL,
  biasadj = FALSE,
  xreg = NULL,
  newxreg = NULL,
  allow.multiplicative.trend = FALSE,
  x = y,
  ...
)
```

```r
## S3 method for class 'stlm'
forecast(
  object,
  h = 2 * object$m,
```
level = c(80, 95),
fan = FALSE,
lambda = object$lambda,
biasadj = NULL,
newxreg = NULL,
allow.multiplicative.trend = FALSE,
...)

stlf(
y,
  h = frequency(x) * 2,
  s.window = 7 + 4 * seq(6),
  t.window = NULL,
  robust = FALSE,
  lambda = NULL,
  biasadj = FALSE,
  x = y,
...)

Arguments

object An object of class stl or stlm. Usually the result of a call to stl or stlm.
method Method to use for forecasting the seasonally adjusted series.
etsmodel The ets model specification passed to ets. By default it allows any non-seasonal
  model. If method!="ets", this argument is ignored.
forecastfunction An alternative way of specifying the function for forecasting the seasonally ad-
  justed series. If forecastfunction is not NULL, then method is ignored. Other-
  wise method is used to specify the forecasting method to be used.
h Number of periods for forecasting.
level Confidence level for prediction intervals.
fan If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.
lambda Box-Cox transformation parameter. If lambda="auto", then a transformation is
  automatically selected using BoxCox. lambda. The transformation is ignored if
  NULL. Otherwise, data transformed before model is estimated.
biasadj Use adjusted back-transformed mean for Box-Cox transformations. If trans-
  formed data is used to produce forecasts and fitted values, a regular back trans-
  formation will result in median forecasts. If biasadj is TRUE, an adjustment will
  be made to produce mean forecasts and fitted values.
xreg Historical regressors to be used in auto.arima() when method=="arima".
newxreg Future regressors to be used in forecast.Arima().
allow.multiplicative.trend If TRUE, then ETS models with multiplicative trends are allowed. Otherwise,
  only additive or no trend ETS models are permitted.
Other arguments passed to `forecast.stl`, `modelfunction` or `forecastfunction`.

- `y`: A univariate numeric time series of class `ts`.
- `s.window`: Either the character string “periodic” or the span (in lags) of the loess window for seasonal extraction.
- `robust`: If `TRUE`, robust fitting will used in the loess procedure within `stl`.
- `modelfunction`: An alternative way of specifying the function for modelling the seasonally adjusted series. If `modelfunction` is not `NULL`, then `method` is ignored. Otherwise method is used to specify the time series model to be used.
- `model`: Output from a previous call to `stlm`. If a `stlm` model is passed, this same model is fitted to `y` without re-estimating any parameters.
- `x`: Deprecated. Included for backwards compatibility.
- `t.window`: A number to control the smoothness of the trend. See `stl` for details.

**Details**

`stlm` takes a time series `y`, applies an STL decomposition, and models the seasonally adjusted data using the model passed as `modelfunction` or specified using `method`. It returns an object that includes the original STL decomposition and a time series model fitted to the seasonally adjusted data. This object can be passed to the `forecast.stlm` for forecasting.

`forecast.stlm` forecasts the seasonally adjusted data, then re-seasonalizes the results by adding back the last year of the estimated seasonal component.

`stlf` combines `stlm` and `forecast.stlm`. It takes a `ts` argument, applies an STL decomposition, models the seasonally adjusted data, reseasonalizes, and returns the forecasts. However, it allows more general forecasting methods to be specified via `forecastfunction`.

`forecast.stl` is similar to `stlf` except that it takes the STL decomposition as the first argument, instead of the time series.

Note that the prediction intervals ignore the uncertainty associated with the seasonal component. They are computed using the prediction intervals from the seasonally adjusted series, which are then reseasonalized using the last year of the seasonal component. The uncertainty in the seasonal component is ignored.

The time series model for the seasonally adjusted data can be specified in `stlm` using either `method` or `modelfunction`. The method argument provides a shorthand way of specifying `modelfunction` for a few special cases. More generally, `modelfunction` can be any function with first argument a `ts` object, that returns an object that can be passed to `forecast`. For example, `forecastfunction=ar` uses the `ar` function for modelling the seasonally adjusted series.

The forecasting method for the seasonally adjusted data can be specified in `stlf` and `forecast.stl` using either `method` or `forecastfunction`. The method argument provides a shorthand way of specifying `forecastfunction` for a few special cases. More generally, `forecastfunction` can be any function with first argument a `ts` object, and other `h` and `level`, which returns an object of class `forecast`. For example, `forecastfunction=thetaf` uses the `thetaf` function for forecasting the seasonally adjusted series.
Value

stlm returns an object of class stlm. The other functions return objects of class forecast.

There are many methods for working with forecast objects including summary to obtain and print a summary of the results, while plot produces a plot of the forecasts and prediction intervals. The generic accessor functions fitted.values and residuals extract useful features.

Author(s)

Rob J Hyndman

See Also

stl, forecast.ets, forecast.Arima.

Examples

tsmod <- stlm(USAccDeaths, modelfunction = ar)
plot(forecast(tsmod, h = 36))

decomp <- stl(USAccDeaths, s.window = "periodic")
plot(forecast(decomp))

plot(stl(AirPassengers, lambda = 0))
forecast.StructTS

Arguments

object
An object of class "StructTS". Usually the result of a call to StructTS.

h
Number of periods for forecasting

level
Confidence level for prediction intervals.

fan
If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.

lambda
Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.

biasadj
Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

... Other arguments.

Details

This function calls predict.StructTS and constructs an object of class "forecast" from the results.

Value

An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by forecast.StructTS.

An object of class "forecast" is a list containing at least the following elements:

model
A list containing information about the fitted model

method
The name of the forecasting method as a character string

mean
Point forecasts as a time series

lower
Lower limits for prediction intervals

upper
Upper limits for prediction intervals

level
The confidence values associated with the prediction intervals

x
The original time series (either object itself or the time series used to create the model stored as object).

residuals
Residuals from the fitted model. That is x minus fitted values.

fitted
Fitted values (one-step forecasts)

Author(s)

Rob J Hyndman
See Also

StructTS.

Examples

```r
fit <- StructTS(WWWusage, "level")
plot(forecast(fit))
```

`fourier`  
*Fourier terms for modelling seasonality*

Description

`fourier` returns a matrix containing terms from a Fourier series, up to order K, suitable for use in Arima, auto.arima, or tslm.

Usage

```r
fourier(x, K, h = NULL)
fourierf(x, K, h)
```

Arguments

- **x**  
  Seasonal time series: a ts or a msts object
- **K**  
  Maximum order(s) of Fourier terms
- **h**  
  Number of periods ahead to forecast (optional)

Details

`fourierf` is deprecated, instead use the h argument in `fourier`.

The period of the Fourier terms is determined from the time series characteristics of x. When h is missing, the length of x also determines the number of rows for the matrix returned by `fourier`. Otherwise, the value of h determines the number of rows for the matrix returned by `fourier`, typically used for forecasting. The values within x are not used.

Typical use would omit h when generating Fourier terms for training a model and include h when generating Fourier terms for forecasting.

When x is a ts object, the value of K should be an integer and specifies the number of sine and cosine terms to return. Thus, the matrix returned has 2*K columns.

When x is a msts object, then K should be a vector of integers specifying the number of sine and cosine terms for each of the seasonal periods. Then the matrix returned will have 2*sum(K) columns.
Value
Numerical matrix.

Author(s)
Rob J Hyndman

See Also
seasonaldummy

Examples

library(ggplot2)

# Using Fourier series for a "ts" object
# K is chosen to minimize the AICc
deaths.model <- auto.arima(USAccDeaths, xreg=fourier(USAccDeaths,K=5), seasonal=FALSE)
dehaths.fcast <- forecast(deaths.model, xreg=fourier(USAccDeaths, K=5, h=36))
autoplot(deaths.fcast) + xlab("Year")

# Using Fourier series for a "msts" object
taylor.lm <- tslm(taylor ~ fourier(taylor, K = c(3, 3)))
taylor.fcast <- forecast(taylor.lm, 
    data.frame(fourier(taylor, K = c(3, 3), h = 270)))
autoplot(taylor.fcast)

gas Australian monthly gas production

Description

Usage
gas

Format
Time series data

Source
Australian Bureau of Statistics.
getResponse

Examples

plot(gas)
seasonplot(gas)
tsdisplay(gas)

getResponse

Get response variable from time series model.

Description

generate is a generic function for extracting the historical data from a time series model (including \textit{Arima}, \textit{ets}, \textit{ar}, \textit{fracdiff}), a linear model of class \textit{lm}, or a forecast object. The function invokes particular \textit{methods} which depend on the class of the first argument.

Usage

generate(object, ...)

## Default S3 method:
generate(object, ...)

## S3 method for class 'lm'
generate(object, ...)

## S3 method for class 'Arima'
generate(object, ...)

## S3 method for class 'fracdiff'
generate(object, ...)

## S3 method for class 'ar'
generate(object, ...)

## S3 method for class 'tbats'
generate(object, ...)

## S3 method for class 'bats'
generate(object, ...)

## S3 method for class 'mforecast'
generate(object, ...)

## S3 method for class 'baggedModel'
generate(object, ...)

# Examples

generate(gas)
gghistogram

Arguments

object  a time series model or forecast object.
...   Additional arguments that are ignored.

Value

A numerical vector or a time series object of class ts.

Author(s)

Rob J Hyndman

Description

Plots a histogram and density estimates using ggplot.

Usage

```r
  gghistogram(  
    x,  
    add.normal = FALSE,  
    add.kde = FALSE,  
    add.rug = TRUE,  
    bins,  
    boundary = 0  
  )
```

Arguments

x  a numerical vector.
add.normal  Add a normal density function for comparison
add.kde  Add a kernel density estimate for comparison
add.rug  Add a rug plot on the horizontal axis
bins  The number of bins to use for the histogram. Selected by default using the Friedman-Diaconis rule given by `nclass.FD`
boundary  A boundary between two bins.

Value

None.
**gglagplot**

**Author(s)**
Rob J Hyndman

**See Also**
`hist`, `geom_histogram`

**Examples**

```r
gghistogram(lynx, add.kde=TRUE)
```

---

**gglagplot**  
*Time series lag ggplots*

**Description**

Plots a lag plot using ggplot.

**Usage**

```r
gglagplot(
  x,
  lags = ifelse(frequency(x) > 9, 16, 9),
  set.lags = 1:lags,
  diag = TRUE,
  diag.col = "gray",
  do.lines = TRUE,
  colour = TRUE,
  continuous = frequency(x) > 12,
  labels = FALSE,
  seasonal = TRUE,
  ...
)
```

```r
gglagchull(
  x,
  lags = ifelse(frequency(x) > 1, min(12, frequency(x)), 4),
  set.lags = 1:lags,
  diag = TRUE,
  diag.col = "gray",
  ...
)
```
Arguments

- **x**: a time series object (type ts).
- **lags**: number of lag plots desired, see arg set.lags.
- **set.lags**: vector of positive integers specifying which lags to use.
- **diag**: logical indicating if the x=y diagonal should be drawn.
- **diag.col**: color to be used for the diagonal if(diag).
- **do.lines**: if TRUE, lines will be drawn, otherwise points will be drawn.
- **colour**: logical indicating if lines should be coloured.
- **continuous**: Should the colour scheme for years be continuous or discrete?
- **labels**: logical indicating if labels should be used.
- **seasonal**: Should the line colour be based on seasonal characteristics (TRUE), or sequential (FALSE).
- ...: Not used (for consistency with lag.plot)

Details

“gglagplot” will plot time series against lagged versions of themselves. Helps visualising ’auto-dependence’ even when auto-correlations vanish.

“gglagchull” will layer convex hulls of the lags, layered on a single plot. This helps visualise the change in ’auto-dependence’ as lags increase.

Value

None.

Author(s)

Mitchell O’Hara-Wild

See Also

lag.plot

Examples

```r
gglagplot(woolyrnq)
gglagplot(woolyrnq, seasonal=FALSE)

lungDeaths <- cbind(mdeaths, fdeaths)
gglagplot(lungDeaths, lags=2)
gglagchull(lungDeaths, lags=6)
gglagchull(woolyrnq)
```
ggmonthplot

Create a seasonal subseries ggplot

Description

Plots a subseries plot using ggplot. Each season is plotted as a separate mini time series. The blue lines represent the mean of the observations within each season.

Usage

ggmonthplot(x, labels = NULL, times = time(x), phase = cycle(x), ...)

ggsubseriesplot(x, labels = NULL, times = time(x), phase = cycle(x), ...)

Arguments

x         a time series object (type ts).
labels    A vector of labels to use for each 'season'
times     A vector of times for each observation
phase     A vector of seasonal components
...       Not used (for consistency with monthplot)

Details

The ggmonthplot function is simply a wrapper for ggsubseriesplot as a convenience for users familiar with monthplot.

Value

Returns an object of class ggplot.

Author(s)

Mitchell O’Hara-Wild

See Also

monthplot

Examples

ggsubseriesplot(AirPassengers)
ggsubseriesplot(woolyrnq)
ggseasonplot

Seasonal plot

Description

Plots a seasonal plot as described in Hyndman and Athanasopoulos (2014, chapter 2). This is like a time plot except that the data are plotted against the seasons in separate years.

Usage

```r
ggseasonplot(
  x,
  season.labels = NULL,
  year.labels = FALSE,
  year.labels.left = FALSE,
  type = NULL,
  col = NULL,
  continuous = FALSE,
  polar = FALSE,
  labelgap = 0.04,
  ...)
```

```r
seasonplot(
  x,
  s,
  season.labels = NULL,
  year.labels = FALSE,
  year.labels.left = FALSE,
  type = "o",
  main,
  xlab = NULL,
  ylab = "",
  col = 1,
  labelgap = 0.1,
  ...)
```

Arguments

- `x` | a numeric vector or time series of class `ts`.
- `season.labels` | Labels for each season in the "year".
- `year.labels` | Logical flag indicating whether labels for each year of data should be plotted on the right.
- `year.labels.left` | Logical flag indicating whether labels for each year of data should be plotted on the left.
ggseasonplot

- type: plot type (as for `plot`). Not yet supported for ggseasonplot.
- col: Colour
- continuous: Should the colour scheme for years be continuous or discrete?
- polar: Plot the graph on seasonal coordinates
- labelgap: Distance between year labels and plotted lines
- ...: additional arguments to `plot`.
- s: seasonal frequency of x
- main: Main title.
- xlab: X-axis label.
- ylab: Y-axis label.

Value

None.

Author(s)

Rob J Hyndman & Mitchell O’Hara-Wild

References


See Also

- `monthplot`

Examples

```r
ggseasonplot(AirPassengers, col=rainbow(12), year.labels=TRUE)
ggseasonplot(AirPassengers, year.labels=TRUE, continuous=TRUE)

seasonplot(AirPassengers, col=rainbow(12), year.labels=TRUE)
```

---

ggtsdisplay | Time series display

Description

Plots a time series along with its acf and either its pacf, lagged scatterplot or spectrum.
Usage

ggtsdisplay(
  x,
  plot.type = c("partial", "histogram", "scatter", "spectrum"),
  points = TRUE,
  smooth = FALSE,
  lag.max,
  na.action = na.contiguous,
  theme = NULL,
  ...
)

tsdisplay(
  x,
  plot.type = c("partial", "histogram", "scatter", "spectrum"),
  points = TRUE,
  ci.type = c("white", "ma"),
  lag.max,
  na.action = na.contiguous,
  main = NULL,
  xlab = "",
  ylab = "",
  pch = 1,
  cex = 0.5,
  ...
)

Arguments

x a numeric vector or time series of class ts.
plot.type type of plot to include in lower right corner.
points logical flag indicating whether to show the individual points or not in the time plot.
smooth logical flag indicating whether to show a smooth loess curve superimposed on the time plot.
lag.max the maximum lag to plot for the acf and pacf. A suitable value is selected by default if the argument is missing.
na.action function to handle missing values in acf, pacf and spectrum calculations. The default is na.contiguous. Useful alternatives are na.pass and na.interp.
theme Adds a ggplot element to each plot, typically a theme.
... additional arguments to acf.
ci.type type of confidence limits for ACF that is passed to acf. Should the confidence limits assume a white noise input or for lag k an MA(k − 1) input?
main Main title.
xlab X-axis label.
gold

Description


Usage

gold

Format

Time series data
Examples

\texttt{tsdisplay(gold)}

\begin{Verbatim}
\textbf{is.acf} \hspace{2em} \textit{Is an object a particular model type?}
\end{Verbatim}

\textbf{Description}

Returns true if the model object is of a particular type

\textbf{Usage}

\begin{verbatim}
is.acf(x)
is.Arima(x)
is.baggedModel(x)
is.bats(x)
is.ets(x)
is.modelAR(x)
is.stlm(x)
is.nnetar(x)
is.nnetarmodels(x)
\end{verbatim}

\textbf{Arguments}

\begin{verbatim}
x \hspace{2em} \text{object to be tested}
\end{verbatim}

\begin{Verbatim}
\textbf{is.constant} \hspace{2em} \textit{Is an object constant?}
\end{Verbatim}

\textbf{Description}

Returns true if the object’s numerical values do not vary.

\textbf{Usage}

\begin{verbatim}
is.constant(x)
\end{verbatim}
is.forecast

Arguments

x  object to be tested

Description

Is an object a particular forecast type?

Returns true if the forecast object is of a particular type

Usage

is.forecast(x)

is.mforecast(x)

is.splineforecast(x)

Arguments

x  object to be tested

ma

Moving-average smoothing

Description

ma computes a simple moving average smoother of a given time series.

Usage

ma(x, order, centre = TRUE)

Arguments

x  Univariate time series

order  Order of moving average smoother

centre  If TRUE, then the moving average is centred for even orders.
Details

The moving average smoother averages the nearest order periods of each observation. As neighbouring observations of a time series are likely to be similar in value, averaging eliminates some of the randomness in the data, leaving a smooth trend-cycle component.

\[
\hat{T}_t = \frac{1}{m} \sum_{j=-k}^{k} y_{t+j}
\]

where \( k = \frac{m-1}{2} \)

When an even order is specified, the observations averaged will include one more observation from the future than the past (k is rounded up). If centre is TRUE, the value from two moving averages (where k is rounded up and down respectively) are averaged, centering the moving average.

Value

Numerical time series object containing the simple moving average smoothed values.

Author(s)

Rob J Hyndman

See Also

decompose

Examples

```r
plot(wineind)
sm <- ma(wineind, order=12)
lines(sm, col="red")
```

<table>
<thead>
<tr>
<th>meanf</th>
<th>Mean Forecast</th>
</tr>
</thead>
</table>

Description

Returns forecasts and prediction intervals for an iid model applied to y.

Usage

```r
meanf(
  y,
  h = 10,
  level = c(80, 95),
  fan = FALSE,
)```
lambda = NULL,
  biasadj = FALSE,
  bootstrap = FALSE,
  npaths = 5000,
  x = y
)

Arguments

y               a numeric vector or time series of class ts
h               Number of periods for forecasting
level           Confidence levels for prediction intervals.
fan             If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.
lambda          Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
biasadj         Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.
bootstrap       If TRUE, use a bootstrap method to compute prediction intervals. Otherwise, assume a normal distribution.
npaths          Number of bootstrapped sample paths to use if bootstrap==TRUE.
x               Deprecated. Included for backwards compatibility.

Details

The iid model is

\[ Y_t = \mu + Z_t \]

where \( Z_t \) is a normal iid error. Forecasts are given by

\[ Y_n(h) = \mu \]

where \( \mu \) is estimated by the sample mean.

Value

An object of class "forecast".
The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.
The generic accessor functions fitted.values and residuals extract useful features of the value returned by meanf.
An object of class "forecast" is a list containing at least the following elements:

  model     A list containing information about the fitted model
  method    The name of the forecasting method as a character string
Point forecasts as a time series
Lower limits for prediction intervals
Upper limits for prediction intervals
The confidence values associated with the prediction intervals
The original time series (either object itself or the time series used to create the model stored as object).
Residuals from the fitted model. That is x minus fitted values.
Fitted values (one-step forecasts)

Author(s)
Rob J Hyndman

See Also
rwf

Examples
nile.fcast <- meanf(Nile, h=10)
plot(nile.fcast)

Description
Experimental function to forecast univariate time series with a user-defined model

Usage
modelAR(
  y,
  p,
  P = 1,
  FUN,
  predict.FUN,
  xreg = NULL,
  lambda = NULL,
  model = NULL,
  subset = NULL,
  scale.inputs = FALSE,
  x = y,
  ...
)

modelAR Time Series Forecasts with a user-defined model
Arguments

- **y**: A numeric vector or time series of class `ts`.
- **p**: Embedding dimension for non-seasonal time series. Number of non-seasonal lags used as inputs. For non-seasonal time series, the default is the optimal number of lags (according to the AIC) for a linear AR(p) model. For seasonal time series, the same method is used but applied to seasonally adjusted data (from an stl decomposition).
- **P**: Number of seasonal lags used as inputs.
- **FUN**: Function used for model fitting. Must accept argument `x` and `y` for the predictors and response, respectively (formula object not currently supported).
- **predict.FUN**: Prediction function used to apply `FUN` to new data. Must accept an object of class `FUN` as its first argument, and a data frame or matrix of new data for its second argument. Additionally, it should return fitted values when new data is omitted.
- **xreg**: Optionally, a vector or matrix of external regressors, which must have the same number of rows as `y`. Must be numeric.
- **lambda**: Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if `NULL`. Otherwise, data transformed before model is estimated.
- **model**: Output from a previous call to `nnetar`. If model is passed, this same model is fitted to `y` without re-estimating any parameters.
- **subset**: Optional vector specifying a subset of observations to be used in the fit. Can be an integer index vector or a logical vector the same length as `y`. All observations are used by default.
- **scale.inputs**: If TRUE, inputs are scaled by subtracting the column means and dividing by their respective standard deviations. If `lambda` is not `NULL`, scaling is applied after Box-Cox transformation.
- **x**: Deprecated. Included for backwards compatibility.
- **...**: Other arguments passed to `FUN` for `modelAR`.

Details

This is an experimental function and only recommended for advanced users. The selected model is fitted with lagged values of `y` as inputs. The inputs are for lags 1 to `p`, and lags `m` to `mP` where `m=frequency(y)`. If `xreg` is provided, its columns are also used as inputs. If there are missing values in `y` or `xreg`, the corresponding rows (and any others which depend on them as lags) are omitted from the fit. The model is trained for one-step forecasting. Multi-step forecasts are computed recursively.

Value

Returns an object of class "modelAR".

The function summary is used to obtain and print a summary of the results.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by `nnetar`. 
model A list containing information about the fitted model
method The name of the forecasting method as a character string
x The original time series.
xreg The external regressors used in fitting (if given).
residuals Residuals from the fitted model. That is x minus fitted values.
fitted Fitted values (one-step forecasts)
... Other arguments

Author(s)
Rob J Hyndman and Gabriel Caceres

Description
Returns number of days in each month or quarter of the observed time period.

Usage
monthdays(x)

Arguments
x time series

Details
Useful for month length adjustments

Value
Time series

Author(s)
Rob J Hyndman

See Also
bizdays
Examples

```r
par(mfrow=c(2,1))
plot(ldeaths,xlab="Year",ylab="pounds",
    main="Monthly deaths from lung disease (UK)"
)
ldeaths.adj <- ldeaths/monthdays(ldeaths)*365.25/12
plot(ldeaths.adj,xlab="Year",ylab="pounds",
    main="Adjusted monthly deaths from lung disease (UK)"
)
```

---

mstl

*Multiple seasonal decomposition*

Description

Decompose a time series into seasonal, trend and remainder components. Seasonal components are estimated iteratively using STL. Multiple seasonal periods are allowed. The trend component is computed for the last iteration of STL. Non-seasonal time series are decomposed into trend and remainder only. In this case, `supsmu` is used to estimate the trend. Optionally, the time series may be Box-Cox transformed before decomposition. Unlike `stl`, `mstl` is completely automated.

Usage

```r
mstl(x, lambda = NULL, iterate = 2, s.window = 7 + 4 * seq(6), ...)
```

Arguments

- **x**: Univariate time series of class `msts` or `ts`.
- **lambda**: Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
- **iterate**: Number of iterations to use to refine the seasonal component.
- **s.window**: Seasonal windows to be used in the decompositions. If scalar, the same value is used for all seasonal components. Otherwise, it should be a vector of the same length as the number of seasonal components (or longer).
- **...**: Other arguments are passed to `stl`.

See Also

- `stl`, `supsmu`

Examples

```r
library(ggplot2)
mstl(taylor) %>% autoplot()
mstl(AirPassengers, lambda = "auto") %>%autoplot()
```
msts

Multi-Seasonal Time Series

Description

msts is an S3 class for multi seasonal time series objects, intended to be used for models that support multiple seasonal periods. The msts class inherits from the ts class and has an additional "msts" attribute which contains the vector of seasonal periods. All methods that work on a ts class, should also work on a msts class.

Usage

msts(data, seasonal.periods, ts.frequency = floor(max(seasonal.periods)), ...)

Arguments

data A numeric vector, ts object, matrix or data frame. It is intended that the time series data is univariate, otherwise treated the same as ts().
seasonal.periods A vector of the seasonal periods of the msts.
ts.frequency The seasonal period that should be used as frequency of the underlying ts object. The default value is max(seasonal.periods).
... Arguments to be passed to the underlying call to ts(). For example start=c(1987,5).

Value

An object of class c("msts","ts"). If there is only one seasonal period (i.e., length(seasonal.periods)==1), then the object is of class "ts".

Author(s)

Slava Razbash and Rob J Hyndman

Examples

x <- msts(taylor, seasonal.periods=c(2*24,2*24*7,2*24*365), start=2000+22/52)
y <- msts(USAccDeaths, seasonal.periods=12, start=1949)
Interpolate missing values in a time series

**Description**

By default, uses linear interpolation for non-seasonal series. For seasonal series, a robust STL decomposition is first computed. Then a linear interpolation is applied to the seasonally adjusted data, and the seasonal component is added back.

**Usage**

```r	na.interp(
  x,
  lambda = NULL,
  linear = (frequency(x) <= 1 | sum(!is.na(x)) <= 2 * frequency(x))
)
```

**Arguments**

- `x` time series
- `lambda` Box-Cox transformation parameter. If `lambda = "auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if `NULL`. Otherwise, data transformed before model is estimated.
- `linear` Should a linear interpolation be used.

**Details**

A more general and flexible approach is available using `na.approx` in the `zoo` package.

**Value**

Time series

**Author(s)**

Rob J Hyndman

**See Also**

`tsoutliers`

**Examples**

```r
data(gold)
plot(na.interp(gold))```
**ndiffs**

*Number of differences required for a stationary series*

**Description**

Functions to estimate the number of differences required to make a given time series stationary. `ndiffs` estimates the number of first differences necessary.

**Usage**

```r
ndiffs(
x,  
alpha = 0.05,  
test = c("kpss", "adf", "pp"),  
type = c("level", "trend"),  
max.d = 2,  
...  
)
```

**Arguments**

- `x` A univariate time series
- `alpha` Level of the test, possible values range from 0.01 to 0.1.
- `test` Type of unit root test to use
- `type` Specification of the deterministic component in the regression
- `max.d` Maximum number of non-seasonal differences allowed
- `...` Additional arguments to be passed on to the unit root test

**Details**

`ndiffs` uses a unit root test to determine the number of differences required for time series `x` to be made stationary. If `test="kpss"`, the KPSS test is used with the null hypothesis that `x` has a stationary root against a unit-root alternative. Then the test returns the least number of differences required to pass the test at the level `alpha`. If `test="adf"`, the Augmented Dickey-Fuller test is used and if `test="pp` the Phillips-Perron test is used. In both of these cases, the null hypothesis is that `x` has a unit root against a stationary root alternative. Then the test returns the least number of differences required to fail the test at the level `alpha`.

**Value**

An integer indicating the number of differences required for stationarity.

**Author(s)**

Rob J Hyndman, Slava Razbash & Mitchell O’Hara-Wild
References


See Also

*auto.arima* and *ndiffs*

Examples

```r
ndiffs(WWWusage)
ndiffs(diff(log(AirPassengers), 12))
```

---

**nnetar**

*Neural Network Time Series Forecasts*

**Description**

Feed-forward neural networks with a single hidden layer and lagged inputs for forecasting univariate time series.

**Usage**

```r
nnetar(
  y,
  p,
  P = 1,
  size,
  repeats = 20,
  xreg = NULL,
  lambda = NULL,
  model = NULL,
  subset = NULL,
  scale.inputs = TRUE,
  x = y,
  ...
)
```
Arguments

- **y**: A numeric vector or time series of class `ts`.
- **p**: Embedding dimension for non-seasonal time series. Number of non-seasonal lags used as inputs. For non-seasonal time series, the default is the optimal number of lags (according to the AIC) for a linear AR(p) model. For seasonal time series, the same method is used but applied to seasonally adjusted data (from an stl decomposition).
- **P**: Number of seasonal lags used as inputs.
- **size**: Number of nodes in the hidden layer. Default is half of the number of input nodes (including external regressors, if given) plus 1.
- **repeats**: Number of networks to fit with different random starting weights. These are then averaged when producing forecasts.
- **xreg**: Optionally, a vector or matrix of external regressors, which must have the same number of rows as `y`. Must be numeric.
- **lambda**: Box-Cox transformation parameter. If `lambda="auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if `NULL`. Otherwise, data transformed before model is estimated.
- **model**: Output from a previous call to `nnetar`. If model is passed, this same model is fitted to `y` without re-estimating any parameters.
- **subset**: Optional vector specifying a subset of observations to be used in the fit. Can be an integer index vector or a logical vector the same length as `y`. All observations are used by default.
- **scale.inputs**: If TRUE, inputs are scaled by subtracting the column means and dividing by their respective standard deviations. If `lambda` is not NULL, scaling is applied after Box-Cox transformation.
- **x**: Deprecated. Included for backwards compatibility.
- **...**: Other arguments passed to `nnet` for `nnetar`.

Details

A feed-forward neural network is fitted with lagged values of `y` as inputs and a single hidden layer with `size` nodes. The inputs are for lags 1 to `p`, and lags `m` to `mP` where `m=frequency(y)`. If `xreg` is provided, its columns are also used as inputs. If there are missing values in `y` or `xreg`, the corresponding rows (and any others which depend on them as lags) are omitted from the fit. A total of `repeats` networks are fitted, each with random starting weights. These are then averaged when computing forecasts. The network is trained for one-step forecasting. Multi-step forecasts are computed recursively.

For non-seasonal data, the fitted model is denoted as an NNAR(p,k) model, where `k` is the number of hidden nodes. This is analogous to an AR(p) model but with nonlinear functions. For seasonal data, the fitted model is called an NNAR(p,P,k)[m] model, which is analogous to an ARIMA(p,0,0)(P,0,0)[m] model but with nonlinear functions.
nsdiffs

Value

Returns an object of class "nnetar".
The function summary is used to obtain and print a summary of the results.
The generic accessor functions fitted.values and residuals extract useful features of the value returned by nnetar.

- **model**: A list containing information about the fitted model
- **method**: The name of the forecasting method as a character string
- **x**: The original time series.
- **xreg**: The external regressors used in fitting (if given).
- **residuals**: Residuals from the fitted model. That is x minus fitted values.
- **fitted**: Fitted values (one-step forecasts)
- **...**: Other arguments

Author(s)

Rob J Hyndman and Gabriel Caceres

Examples

```r
fit <- nnetar(lynx)
fcast <- forecast(fit)
plot(fcast)

## Arguments can be passed to nnet()
fit <- nnetar(lynx, decay=0.5, maxit=150)
plot(forecast(fit))
lines(lynx)

## Fit model to first 100 years of lynx data
fit <- nnetar(window(lynx,end=1920), decay=0.5, maxit=150)
plot(forecast(fit,h=14))
lines(lynx)

## Apply fitted model to later data, including all optional arguments
fit2 <- nnetar(window(lynx,start=1921), model=fit)
```

<table>
<thead>
<tr>
<th>nsdiffs</th>
<th>Number of differences required for a seasonally stationary series</th>
</tr>
</thead>
</table>

Description

Functions to estimate the number of differences required to make a given time series stationary. nsdiffs estimates the number of seasonal differences necessary.
Usage

nsdiffs(
  x,
  alpha = 0.05,
  m = frequency(x),
  test = c("seas", "ocsb", "hegy", "ch"),
  max.D = 1,
  ...
)

Arguments

x         A univariate time series
alpha     Level of the test, possible values range from 0.01 to 0.1.
m        Deprecated. Length of seasonal period
test     Type of unit root test to use
max.D     Maximum number of seasonal differences allowed
...      Additional arguments to be passed on to the unit root test

Details

nsdiffs uses seasonal unit root tests to determine the number of seasonal differences required for
time series x to be made stationary (possibly with some lag-one differencing as well).

Several different tests are available:

- If test="seas" (default), a measure of seasonal strength is used, where differencing is se-
  lected if the seasonal strength (Wang, Smith & Hyndman, 2006) exceeds 0.64 (based on min-
  imizing MASE when forecasting using auto.arima on M3 and M4 data).
- If test="ch", the Canova-Hansen (1995) test is used (with null hypothesis of deterministic
  seasonality)
- If test="hegy", the Hylleberg, Engle, Granger & Yoo (1990) test is used.
- If test="ocsb", the Osborn-Chui-Smith-Birchenhall (1988) test is used (with null hypothesis
  that a seasonal unit root exists).

Value

An integer indicating the number of differences required for stationarity.

Author(s)

Rob J Hyndman, Slava Razbash and Mitchell O’Hara-Wild
An implementation of the Osborn, Chui, Smith, and Birchenhall (OCSB) test.

**Usage**

```r
ocsb.test(x, lag.method = c("fixed", "AIC", "BIC", "AICc"), maxlag = 0)
```

**Arguments**

- `x`: a univariate seasonal time series.
- `lag.method`: a character specifying the lag order selection method.
- `maxlag`: the maximum lag order to be considered by `lag.method`.

**Details**

The regression equation may include lags of the dependent variable. When `lag.method = "fixed"`, the lag order is fixed to `maxlag`; otherwise, `maxlag` is the maximum number of lags considered in a lag selection procedure that minimises the `lag.method` criterion, which can be AIC or BIC or corrected AIC, AICC, obtained as AIC + (2k(k+1))/(n-k-1), where k is the number of parameters and n is the number of available observations in the model.

Critical values for the test are based on simulations, which has been smoothed over to produce critical values for all seasonal periods.
Value

`ocsb.test` returns a list of class "OCSBtest" with the following components:  
* `statistics` the value of the test statistics.  
* `pvalues` the p-values for each test statistics.  
* `method` a character string describing the type of test.  
* `data.name` a character string giving the name of the data.  
* `fitted.model` the fitted regression model.

References


See Also

`nsdiffs`

Examples

```r
ocsb.test(AirPassengers)
```

## plot.Arima

### Plot characteristic roots from ARIMA model

Description

Produces a plot of the inverse AR and MA roots of an ARIMA model. Inverse roots outside the unit circle are shown in red.

Usage

```r
## S3 method for class 'Arima'
plot(
x,
  type = c("both", "ar", "ma"),
  main,
  xlab = "Real",
  ylab = "Imaginary",
  ...
)

## S3 method for class 'ar'
plot(x, main, xlab = "Real", ylab = "Imaginary", ...)

## S3 method for class 'Arima'
autoplot(object, type = c("both", "ar", "ma"), ...)

## S3 method for class 'ar'
autoplot(object, ...)
```
plot.Arima

Arguments

- **x**: Object of class “Arima” or “ar”.
- **type**: Determines if both AR and MA roots are plotted, or if just one set is plotted.
- **main**: Main title. Default is "Inverse AR roots" or "Inverse MA roots".
- **xlab**: X-axis label.
- **ylab**: Y-axis label.
- **...**: Other plotting parameters passed to `par`.
- **object**: Object of class “Arima” or “ar”. Used for ggplot graphics (S3 method consistency).

Details

`autoplot` will produce an equivalent plot as a ggplot object.

Value

None. Function produces a plot

Author(s)

Rob J Hyndman & Mitchell O’Hara-Wild

See Also

`Arima`, `ar`

Examples

```r
library(ggplot2)

fit <- Arima(WWWusage, order = c(3, 1, 0))
plot(fit)
autoplot(fit)

fit <- Arima(woolyrnq, order = c(2, 0, 0), seasonal = c(2, 1, 1))
plot(fit)
autoplot(fit)

plot(ar.ols(gold[1:61]))
autoplot(ar.ols(gold[1:61]))
```
plot.bats

Plot components from BATS model

Description

Produces a plot of the level, slope and seasonal components from a BATS or TBATS model. The plotted components are Box-Cox transformed using the estimated transformation parameter.

Usage

## S3 method for class 'bats'
plot(x, main = "Decomposition by BATS model", ...)

## S3 method for class 'tbats'
autoplot(object, range.bars = FALSE, ...)

## S3 method for class 'bats'
autoplot(object, range.bars = FALSE, ...)

## S3 method for class 'tbats'
plot(x, main = "Decomposition by TBATS model", ...)

Arguments

x Object of class “bats/tbats”.
main Main title for plot.
... Other plotting parameters passed to par.
object Object of class “bats/tbats”.
range.bars Logical indicating if each plot should have a bar at its right side representing relative size. If NULL, automatic selection takes place.

Value

None. Function produces a plot.

Author(s)

Rob J Hyndman

See Also

bats, tbats
Examples

```r
## Not run:
fit <- tbats(USAccDeaths)
plot(fit)
autoplot(fit, range.bars = TRUE)
## End(Not run)
```

**plot.ets**  
*Plot components from ETS model*

**Description**  
Produces a plot of the level, slope and seasonal components from an ETS model.

**Usage**  
```r
## S3 method for class 'ets'
plot(x, ...)
```

```r
## S3 method for class 'ets'
autoplot(object, range.bars = NULL, ...)
```

**Arguments**  
x Object of class “ets”.
...
Other plotting parameters to affect the plot.
object Object of class “ets”. Used for ggplot graphics (S3 method consistency).
range.bars Logical indicating if each plot should have a bar at its right side representing relative size. If NULL, automatic selection takes place.

**Details**  
`autoplot` will produce an equivalent plot as a ggplot object.

**Value**  
None. Function produces a plot

**Author(s)**  
Rob J Hyndman & Mitchell O’Hara-Wild

**See Also**  
ets
Examples

```r
fit <- ets(USAccDeaths)
plot(fit)
plot(fit, plot.type="single", ylab="", col=1:3)

library(ggplot2)
autoplot(fit)
```

**plot.forecast**  
*Forecast plot*

**Description**

Plots historical data with forecasts and prediction intervals.

**Usage**

```r
## S3 method for class 'forecast'
plot(
x,  
include,  
PI = TRUE,  
showgap = TRUE,  
shaded = TRUE,  
shadebars = (length(x$mean) < 5),  
shadecols = NULL,  
col = 1,  
fcol = 4,  
pi.col = 1,  
pi.lty = 2,  
ylim = NULL,  
main = NULL,  
xlab = "",  
ylab = "",  
type = "l",  
flty = 1,  
flwd = 2,  
...  
)

## S3 method for class 'forecast'
autoplot(
object,  
include,  
PI = TRUE,
```
```r
shadecols = c("#596DD5", "#D5DBFF"),
fcol = "#0000AA",
flwd = 0.5,
...)
```
object  Forecast object produced by forecast. Used for ggplot graphics (S3 method consistency).
series  Matches an unidentified forecast layer with a coloured object on the plot.
fitcol  Line colour for fitted values.
pch    Plotting character (if type=="p" or type=="o").

Details

autoplot will produce a ggplot object.
plot.splineforecast autoplot.splineforecast

Value

None.

Author(s)

Rob J Hyndman & Mitchell O’Hara-Wild

References


See Also

plot.ts

Examples

library(ggplot2)

wine.fit <- hw(wineind,h=48)
plot(wine.fit)
autoplot(wine.fit)

fit <- tslm(wineind ~ fourier(wineind,4))
fcast <- forecast(fit, newdata=data.frame(fourier(wineind,4,20)))
autoplot(fcast)

fcast <- splinef(airmiles,h=5)
plot(fcast)
autoplot(fcast)
Description

Returns time series of residuals from a fitted model.

Usage

```
## S3 method for class 'forecast'
residuals(object, type = c("innovation", "response"), ...)

## S3 method for class 'ar'
residuals(object, type = c("innovation", "response"), ...)

## S3 method for class 'Arima'
residuals(object, type = c("innovation", "response", "regression"), h = 1, ...)

## S3 method for class 'bats'
residuals(object, type = c("innovation", "response"), h = 1, ...)

## S3 method for class 'tbats'
residuals(object, type = c("innovation", "response"), h = 1, ...)

## S3 method for class 'ets'
residuals(object, type = c("innovation", "response"), h = 1, ...)

## S3 method for class 'ARFIMA'
residuals(object, type = c("innovation", "response"), ...)

## S3 method for class 'nnetar'
residuals(object, type = c("innovation", "response"), h = 1, ...)

## S3 method for class 'stlm'
residuals(object, type = c("innovation", "response"), ...)

## S3 method for class 'tslm'
residuals(object, type = c("innovation", "response", "deviance"), ...)
```

Arguments

- **object**: An object containing a time series model of class ar, Arima, bats, ets, arfima, nnetar or stlm. If object is of class forecast, then the function will return object$residuals if it exists, otherwise it returns the differences between the observations and their fitted values.

- **type**: Type of residual.
Other arguments not used.

If type='response', then the fitted values are computed for h-step forecasts.

Details

Innovation residuals correspond to the white noise process that drives the evolution of the time series model. Response residuals are the difference between the observations and the fitted values (equivalent to h-step forecasts). For functions with no h argument, h=1. For homoscedastic models, the innovation residuals and the response residuals for h=1 are identical. Regression residuals are available for regression models with ARIMA errors, and are equal to the original data minus the effect of the regression variables. If there are no regression variables, the errors will be identical to the original series (possibly adjusted to have zero mean). arima.residuals is a deprecated function which is identical to residuals.Arima(object,type="regression"). For nnetar objects, when type="innovations" and lambda is used, a matrix of time-series consisting of the residuals from each of the fitted neural networks is returned.

Value

A ts object.

Author(s)

Rob J Hyndman

See Also

fitted.Arima, checkresiduals.

Examples

```r
fit <- Arima(lynx, order=c(4,0,0), lambda=0.5)
plot(residuals(fit))
plot(residuals(fit, type='response'))
```

Description

rwf() returns forecasts and prediction intervals for a random walk with drift model applied to y. This is equivalent to an ARIMA(0,1,0) model with an optional drift coefficient. naive() is simply a wrapper to rwf() for simplicity. snaive() returns forecasts and prediction intervals from an ARIMA(0,0,0)(0,1,0)m model where m is the seasonal period.
**Usage**

```
rwf(
  y,
  h = 10,
  drift = FALSE,
  level = c(80, 95),
  fan = FALSE,
  lambda = NULL,
  biasadj = FALSE,
  ..., 
  x = y
)
```

```
naiive(
  y,
  h = 10,
  level = c(80, 95),
  fan = FALSE,
  lambda = NULL,
  biasadj = FALSE,
  ..., 
  x = y
)
```

```
snaive(
  y,
  h = 2 * frequency(x),
  level = c(80, 95),
  fan = FALSE,
  lambda = NULL,
  biasadj = FALSE,
  ..., 
  x = y
)
```

**Arguments**

- **y** a numeric vector or time series of class ts
- **h** Number of periods for forecasting
- **drift** Logical flag. If TRUE, fits a random walk with drift model.
- **level** Confidence levels for prediction intervals.
- **fan** If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.
- **lambda** Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox::lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
biasadj  Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

Additional arguments affecting the forecasts produced. If model=NULL, forecast.ts passes these to ets or stlf depending on the frequency of the time series. If model is not NULL, the arguments are passed to the relevant modelling function.

x  Deprecated. Included for backwards compatibility.

Details

The random walk with drift model is

$Y_t = c + Y_{t-1} + Z_t$

where $Z_t$ is a normal iid error. Forecasts are given by

$Y_n(h) = ch + Y_n$

If there is no drift (as in naive), the drift parameter $c=0$. Forecast standard errors allow for uncertainty in estimating the drift parameter (unlike the corresponding forecasts obtained by fitting an ARIMA model directly).

The seasonal naive model is

$Y_t = Y_{t-m} + Z_t$

where $Z_t$ is a normal iid error.

Value

An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by naive or snaive.

An object of class "forecast" is a list containing at least the following elements:

- model  A list containing information about the fitted model
- method  The name of the forecasting method as a character string
- mean  Point forecasts as a time series
- lower  Lower limits for prediction intervals
- upper  Upper limits for prediction intervals
- level  The confidence values associated with the prediction intervals
- x  The original time series (either object itself or the time series used to create the model stored as object).
- residuals  Residuals from the fitted model. That is x minus fitted values.
- fitted  Fitted values (one-step forecasts)
seasadj

Author(s)
Rob J Hyndman

See Also
Arima

Examples

```r
gold.fcast <- rwf(gold[1:60], h=50)
plot(gold.fcast)

plot(naive(gold,h=50),include=200)

plot(snaive(wineind))
```

Description

Returns seasonally adjusted data constructed by removing the seasonal component.

Usage

```r
seasadj(object, ...)
```

## S3 method for class 'stl'
seasadj(object, ...)

## S3 method for class 'mstl'
seasadj(object, ...)

## S3 method for class 'decomposed.ts'
seasadj(object, ...)

## S3 method for class 'tbats'
seasadj(object, ...)

## S3 method for class 'seas'
seasadj(object, ...)

seasadj                  Seasonal adjustment
Arguments

object Object created by `decompose`, `stl` or `tbats`.
...

Other arguments not currently used.

Value

Univariate time series.

Author(s)

Rob J Hyndman

See Also

`stl`, `decompose`, `tbats`.

Examples

```r
plot(AirPassengers)
lines(seasadj(decompose(AirPassengers,"multiplicative"), col=4))
```

seasonal

*Extract components from a time series decomposition*

Description

Returns a univariate time series equal to either a seasonal component, trend-cycle component or remainder component from a time series decomposition.

Usage

```r
seasonal(object)
trendcycle(object)
remainder(object)
```

Arguments

object Object created by `decompose`, `stl` or `tbats`.

Value

Univariate time series.
seasonaldummy

Author(s)
Rob J Hyndman

See Also
stl, decompose, tbats, seasadj.

Examples
plot(USAccDeaths)
fit <- stl(USAccDeaths, s.window="periodic")
lines(trendcycle(fit), col="red")

library(ggplot2)
autoplot(cbind(
  Data=USAccDeaths,
  Seasonal=seasonal(fit),
  Trend=trendcycle(fit),
  Remainder=remainder(fit)),
  facets=TRUE) +
  ylab("") + xlab("Year")

seasonaldummy Seasonal dummy variables

Description
seasonaldummy returns a matrix of dummy variables suitable for use in Arima, auto.arima or tslm. The last season is omitted and used as the control.

Usage
seasonaldummy(x, h = NULL)
seasonaldummyf(x, h)

Arguments
x Seasonal time series: a ts or a msts object
h Number of periods ahead to forecast (optional)

Details
seasonaldummyf is deprecated, instead use the h argument in seasonaldummy.
The number of dummy variables is determined from the time series characteristics of x. When h is missing, the length of x also determines the number of rows for the matrix returned by seasonaldummy. The value of h determines the number of rows for the matrix returned by seasonaldummy, typically used for forecasting. The values within x are not used.
Value

Numerical matrix.

Author(s)

Rob J Hyndman

See Also

fourier

Examples

plot(ldeaths)

# Using seasonal dummy variables
month <- seasonaldummy(ldeaths)
deaths.lm <- tslm(ldeaths ~ month)
tsdisplay(residuals(deaths.lm))
deaths.fcast <- forecast(deaths.lm,
    data.frame(month=I(seasonaldummy(ldeaths,36))))
plot(deaths.fcast)

# A simpler approach to seasonal dummy variables
deaths.lm <- tslm(ldeaths ~ season)
deaths.fcast <- forecast(deaths.lm, h=36)
plot(deaths.fcast)

ses

Exponential smoothing forecasts

Description

Returns forecasts and other information for exponential smoothing forecasts applied to y.

Usage

ses(
    y,
    h = 10,
    level = c(80, 95),
    fan = FALSE,
    initial = c("optimal", "simple"),
    alpha = NULL,
    lambda = NULL,
    biasadj = FALSE,
Arguments

\( y \)  
a numeric vector or time series of class ts

\( h \)  
Number of periods for forecasting.

\( \text{level} \)  
Confidence level for prediction intervals.

\( \text{fan} \)  
If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.

\( \text{initial} \)  
Method used for selecting initial state values. If \text{optimal}, the initial values are optimized along with the smoothing parameters using \text{ets}. If \text{simple}, the
initial values are set to values obtained using simple calculations on the first few observations. See Hyndman & Athanasopoulos (2014) for details.

**alpha** Value of smoothing parameter for the level. If NULL, it will be estimated.

**lambda** Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.

**biasadj** Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

**x** Deprecated. Included for backwards compatibility.

... Other arguments passed to forecast.ets.

**damped** If TRUE, use a damped trend.

**exponential** If TRUE, an exponential trend is fitted. Otherwise, the trend is (locally) linear.

**beta** Value of smoothing parameter for the trend. If NULL, it will be estimated.

**phi** Value of damping parameter if damped=TRUE. If NULL, it will be estimated.

**seasonal** Type of seasonality in hw model. "additive" or "multiplicative"

**gamma** Value of smoothing parameter for the seasonal component. If NULL, it will be estimated.

**Details**

ses, holt and hw are simply convenient wrapper functions for forecast(ets(...)).

**Value**

An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by ets and associated functions.

An object of class "forecast" is a list containing at least the following elements:

**model** A list containing information about the fitted model

**method** The name of the forecasting method as a character string

**mean** Point forecasts as a time series

**lower** Lower limits for prediction intervals

**upper** Upper limits for prediction intervals

**level** The confidence values associated with the prediction intervals

**x** The original time series (either object itself or the time series used to create the model stored as object).

**residuals** Residuals from the fitted model.

**fitted** Fitted values (one-step forecasts)
**Description**

Returns a time series based on the model object object.

**Usage**

```r
## S3 method for class 'ets'
simulate(
  object,
  nsim = length(object$x),
  seed = NULL,
  future = TRUE,
  bootstrap = FALSE,
  innov = NULL,
  ...
)

## S3 method for class 'Arima'
simulate(
  object,
```
nsim = length(object$x),
seed = NULL,
xreg = NULL,
future = TRUE,
bootstrap = FALSE,
innov = NULL,
lambda = object$lambda,
...
)

## S3 method for class 'ar'
simulate(
  object,
  nsim = object$n.used,
  seed = NULL,
  future = TRUE,
  bootstrap = FALSE,
  innov = NULL,
  ...
)

## S3 method for class 'lagwalk'
simulate(
  object,
  nsim = length(object$x),
  seed = NULL,
  future = TRUE,
  bootstrap = FALSE,
  innov = NULL,
  lambda = object$lambda,
  ...
)

## S3 method for class 'fracdiff'
simulate(
  object,
  nsim = object$n,
  seed = NULL,
  future = TRUE,
  bootstrap = FALSE,
  innov = NULL,
  ...
)

## S3 method for class 'nnetar'
simulate(
  object,
  nsim = length(object$x),
seed = NULL,
xreg = NULL,
future = TRUE,
bootstrap = FALSE,
innov = NULL,
lambda = object$lambda,
...
)}

## S3 method for class 'modelAR'
simulate(
    object,
    nsim = length(object$x),
    seed = NULL,
    xreg = NULL,
    future = TRUE,
    bootstrap = FALSE,
    innov = NULL,
    lambda = object$lambda,
    ...
)

Arguments

object
An object of class "ets", "Arima", "ar" or "nnetar".

nsim
Number of periods for the simulated series. Ignored if either xreg or innov are not NULL.

seed
Either NULL or an integer that will be used in a call to set.seed before simulating the time series. The default, NULL, will not change the random generation state.

future
Produce sample paths that are future to and conditional on the data in object. Otherwise simulate unconditionally.

bootstrap
Do simulation using resampled errors rather than normally distributed errors or errors provided as innov.

innov
A vector of innovations to use as the error series. Ignored if bootstrap==TRUE. If not NULL, the value of nsim is set to length of innov.

... Other arguments, not currently used.

xreg
New values of xreg to be used for forecasting. The value of nsim is set to the number of rows of xreg if it is not NULL.

lambda
Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.

Details

With simulate.Arima(), the object should be produced by Arima or auto.arima, rather than arima. By default, the error series is assumed normally distributed and generated using rnorm. If
inov is present, it is used instead. If bootstrap=TRUE and innov=NULL, the residuals are resampled instead.

When future=TRUE, the sample paths are conditional on the data. When future=FALSE and the model is stationary, the sample paths do not depend on the data at all. When future=FALSE and the model is non-stationary, the location of the sample paths is arbitrary, so they all start at the value of the first observation.

Value

An object of class "ts".

Author(s)

Rob J Hyndman

See Also

ets, Arima, auto.arima, ar, arfima, nnetar.

Examples

fit <- ets(USAccDeaths)
plot(USAccDeaths, xlim=c(1973,1982))
lines(simulate(fit, 36), col="red")

sindexf       Forecast seasonal index

Description

Returns vector containing the seasonal index for h future periods. If the seasonal index is non-periodic, it uses the last values of the index.

Usage

sindexf(object, h)

Arguments

object  Output from decompose or stl.

h       Number of periods ahead to forecast

Value

Time series
splinef

Author(s)
Rob J Hyndman

Examples
uk.stl <- stl(UKDriverDeaths,"periodic")
uk.sa <- seasadj(uk.stl)
uk.fcast <- holt(uk.sa,36)
seasf <- sindexf(uk.stl,36)
uk.fcast$mean <- uk.fcast$mean + seasf
uk.fcast$lower <- uk.fcast$lower + cbind(seasf,seasf)
uk.fcast$upper <- uk.fcast$upper + cbind(seasf,seasf)
uk.fcast$x <- UKDriverDeaths
plot(uk.fcast,main="Forecasts from Holt's method with seasonal adjustment")

splinef  

Cubic Spline Forecast

Description
Returns local linear forecasts and prediction intervals using cubic smoothing splines.

Usage
splinef(
y,    
h = 10,    
level = c(80, 95),    
fan = FALSE,    
lambda = NULL,    
biasadj = FALSE,    
method = c("gcv", "mle"),    
x = y
)

Arguments
y       a numeric vector or time series of class ts
h       Number of periods for forecasting
level   Confidence level for prediction intervals.
fan     If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.
lambda  Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.
Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

Method for selecting the smoothing parameter. If method="gcv", the generalized cross-validation method from smooth.spline is used. If method="mle", the maximum likelihood method from Hyndman et al (2002) is used.

Deprecated. Included for backwards compatibility.

The cubic smoothing spline model is equivalent to an ARIMA(0,2,2) model but with a restricted parameter space. The advantage of the spline model over the full ARIMA model is that it provides a smooth historical trend as well as a linear forecast function. Hyndman, King, Pitrun, and Billah (2002) show that the forecast performance of the method is hardly affected by the restricted parameter space.

An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by splinef.

An object of class "forecast" containing the following elements:

A list containing information about the fitted model
The name of the forecasting method as a character string
Point forecasts as a time series
Lower limits for prediction intervals
Upper limits for prediction intervals
The confidence values associated with the prediction intervals
The original time series (either object itself or the time series used to create the model stored as object).
One-step forecasts from the fitted model.
Smooth estimates of the fitted trend using all data.
Residuals from the fitted model. That is x minus one-step forecasts.

Rob J Hyndman

See Also

smooth.spline, arima, holt.

Examples

```r
fcast <- splinef(uspop,h=5)
pplot(fcast)
summary(fcast)
```

Description

Generates forecasts from forecast.ts and adds them to the plot. Forecasts can be modified via sending forecast specific arguments above.

Usage

StatForecast

GeomForecast

ggeom_forecast(
mapping = NULL,
data = NULL,
stat = "forecast",
position = "identity",
na.rm = FALSE,
show.legend = NA,
inherit.aes = NA,
PI = TRUE,
showgap = TRUE,
series = NULL,
...)

Arguments

mapping Set of aesthetic mappings created by aes or aes_. If specified and inherit.aes = TRUE (the default), it is combined with the default mapping at the top level of the plot. You must supply mapping if there is no plot mapping.

data The data to be displayed in this layer. There are three options:
If NULL, the default, the data is inherited from the plot data as specified in the call to ggplot.
A `data.frame`, or other object, will override the plot data. All objects will be fortified to produce a data frame. See `fortify` for which variables will be created.

A function will be called with a single argument, the plot data. The return value must be a `data.frame`, and will be used as the layer data.

- **stat**: The stat object to use to calculate the data.
- **position**: Position adjustment, either as a string, or the result of a call to a position adjustment function.
- **na.rm**: If FALSE (the default), removes missing values with a warning. If TRUE silently removes missing values.
- **show.legend**: logical. Should this layer be included in the legends? NA, the default, includes if any aesthetics are mapped. FALSE never includes, and TRUE always includes.
- **inherit.aes**: If FALSE, overrides the default aesthetics, rather than combining with them. This is most useful for helper functions that define both data and aesthetics and shouldn’t inherit behaviour from the default plot specification, e.g. `borders`.
- **PI**: If FALSE, confidence intervals will not be plotted, giving only the forecast line.
- **showgap**: If `showgap=FALSE`, the gap between the historical observations and the forecasts is removed.
- **series**: Matches an unidentified forecast layer with a coloured object on the plot.
- **...**: Additional arguments for `forecast.ts`, other arguments are passed on to `layer`. These are often aesthetics, used to set an aesthetic to a fixed value, like `color = "red"` or `alpha = .5`. They may also be parameters to the paired geom/stat.

### Format

An object of class `StatForecast` (inherits from `Stat, ggproto, gg`) of length 3.

An object of class `GeomForecast` (inherits from `Geom, ggproto, gg`) of length 7.

### Details

Multivariate forecasting is supported by having each time series on a different group.

You can also pass `geom_forecast` a `forecast` object to add it to the plot.

The aesthetics required for the forecasting to work includes forecast observations on the y axis, and the time of the observations on the x axis. Refer to the examples below. To automatically set up aesthetics, use `autoplot`.

### Value

A layer for a ggplot graph.

### Author(s)

Mitchell O’Hara-Wild

### See Also

`forecast, ggproto`
Examples

```r
## Not run:
library(ggplot2)
autoplot(USAccDeaths) + geom_forecast()

lungDeaths <- cbind(mdeaths, fdeaths)
autoplot(lungDeaths) + geom_forecast()

# Using fortify.ts
p <- ggplot(aes(x=x, y=y), data=USAccDeaths)
p <- p + geom_line()
p + geom_forecast()

# Without fortify.ts
data <- data.frame(USAccDeaths=as.numeric(USAccDeaths), time=as.numeric(time(USAccDeaths)))
p <- ggplot(aes(x=time, y=USAccDeaths), data=data)
p <- p + geom_line()
p + geom_forecast()

p + geom_forecast(h=60)
p <- ggplot(aes(x=time, y=USAccDeaths), data=data)
p + geom_forecast(level=c(70,98))
p + geom_forecast(level=c(70,98), colour="lightblue")

# Add forecasts to multivariate series with colour groups
lungDeaths <- cbind(mdeaths, fdeaths)
autoplot(lungDeaths) + geom_forecast(forecast(mdeaths), series="mdeaths")

## End(Not run)
```

---

**subset.ts**  
*Subsetting a time series*

**Description**

Various types of subsetting of a time series. Allows subsetting by index values (unlike `window`). Also allows extraction of the values of a specific season or subset of seasons in each year. For example, to extract all values for the month of May from a time series.

**Usage**

```r
## S3 method for class 'ts'
subset(
  x,
  subset = NULL,
  month = NULL,
  quarter = NULL,
)```
## S3 method for class 'msts'
subset(x, subset = NULL, start = NULL, end = NULL, ...)

### Arguments

- **x**: a univariate time series to be subsetted
- **subset**: optional logical expression indicating elements to keep; missing values are taken as false. subset must be the same length as x.
- **month**: Numeric or character vector of months to retain. Partial matching on month names used.
- **quarter**: Numeric or character vector of quarters to retain.
- **season**: Numeric vector of seasons to retain.
- **start**: Index of start of contiguous subset.
- **end**: Index of end of contiguous subset.
- **...**: Other arguments, unused.

### Details

If character values for months are used, either upper or lower case may be used, and partial unambiguous names are acceptable. Possible character values for quarters are "Q1", "Q2", "Q3", and "Q4".

### Value

If subset is used, a numeric vector is returned with no ts attributes. If start and/or end are used, a ts object is returned consisting of x[start:end], with the appropriate time series attributes retained. Otherwise, a ts object is returned with frequency equal to the length of month, quarter or season.

### Author(s)

Rob J Hyndman

### See Also

- `subset`, `window`

### Examples

```r
plot(subset(gas, month="November"))
subset(woolyrnq, quarter=3)
subset(USAccDeaths, start=49)
```
**taylor**

*Half-hourly electricity demand*

**Description**

Half-hourly electricity demand in England and Wales from Monday 5 June 2000 to Sunday 27 August 2000. Discussed in Taylor (2003), and kindly provided by James W Taylor. Units: Megawatts

**Usage**

taylor

**Format**

Time series data

**Source**

James W Taylor

**References**


**Examples**

plot(taylor)

---

**tbats**

*TBATS model (Exponential smoothing state space model with Box-Cox transformation, ARMA errors, Trend and Seasonal components)*

**Description**

Fits a TBATS model applied to \( y \), as described in De Livera, Hyndman & Snyder (2011). Parallel processing is used by default to speed up the computations.
Usage

tbats(
  y,
  use.box.cox = NULL,
  use.trend = NULL,
  use.damped.trend = NULL,
  seasonal.periods = NULL,
  use.arma.errors = TRUE,
  use.parallel = length(y) > 1000,
  num.cores = 2,
  bc.lower = 0,
  bc.upper = 1,
  biasadj = FALSE,
  model = NULL,
  ...
)

Arguments

y                     The time series to be forecast. Can be numeric, msts or ts. Only univariate time series are supported.
use.box.cox           TRUE/FALSE indicates whether to use the Box-Cox transformation or not. If NULL then both are tried and the best fit is selected by AIC.
use.trend             TRUE/FALSE indicates whether to include a trend or not. If NULL then both are tried and the best fit is selected by AIC.
use.damped.trend      TRUE/FALSE indicates whether to include a damping parameter in the trend or not. If NULL then both are tried and the best fit is selected by AIC.
seasonal.periods      If y is numeric then seasonal periods can be specified with this parameter.
use.arma.errors       TRUE/FALSE indicates whether to include ARMA errors or not. If TRUE the best fit is selected by AIC. If FALSE then the selection algorithm does not consider ARMA errors.
use.parallel          TRUE/FALSE indicates whether or not to use parallel processing.
num.cores             The number of parallel processes to be used if using parallel processing. If NULL then the number of logical cores is detected and all available cores are used.
bc.lower              The lower limit (inclusive) for the Box-Cox transformation.
bc.upper              The upper limit (inclusive) for the Box-Cox transformation.
biasadj              Use adjusted back-transformed mean for Box-Cox transformations. If TRUE, point forecasts and fitted values are mean forecast. Otherwise, these points can be considered the median of the forecast densities.
model                 Output from a previous call to tbats. If model is passed, this same model is fitted to y without re-estimating any parameters.
... Additional arguments to be passed to auto.arima when choose an ARMA(p, q) model for the errors. (Note that xreg will be ignored, as will any arguments concerning seasonality and differencing, but arguments controlling the values of p and q will be used.)

Value

An object with class c("tbats","bats"). The generic accessor functions fitted.values and residuals extract useful features of the value returned by bats and associated functions. The fitted model is designated TBATS(omega, p,q, phi, <m1,k1>,...,<mJ,kJ>) where omega is the Box-Cox parameter and phi is the damping parameter; the error is modelled as an ARMA(p,q) process and m1,...,mJ list the seasonal periods used in the model and k1,...,kJ are the corresponding number of Fourier terms used for each seasonality.

Author(s)

Slava Razbash and Rob J Hyndman

References


See Also

tbats.components.

Examples

```r
## Not run:
fit <- tbats(USAccDeaths)
plot(forecast(fit))
taylor.fit <- tbats(taylor)
plot(forecast(taylor.fit))
## End(Not run)
```

tbats.components Extract components of a TBATS model

Description

Extract the level, slope and seasonal components of a TBATS model. The extracted components are Box-Cox transformed using the estimated transformation parameter.
Usage

tbats.components(x)

Arguments

x

A tbats object created by `tbats`.

Value

A multiple time series (`mts`) object. The first series is the observed time series. The second series is the trend component of the fitted model. Series three onwards are the seasonal components of the fitted model with one time series for each of the seasonal components. All components are transformed using estimated Box-Cox parameter.

Author(s)

Slava Razbash and Rob J Hyndman

References


See Also

`tbats`.

Examples

```r
## Not run:
fit <- tbats(USAccDeaths, use.parallel=FALSE)
components <- tbats.components(fit)
plot(components)
## End(Not run)
```

---

### thetaf

*Theta method forecast*

**Description**

Returns forecasts and prediction intervals for a theta method forecast.
thetaf

Usage

thetaf(
  y,
  h = ifelse(frequency(y) > 1, 2 * frequency(y), 10),
  level = c(80, 95),
  fan = FALSE,
  x = y
)

Arguments

y a numeric vector or time series of class ts
h Number of periods for forecasting
level Confidence levels for prediction intervals.
fan If TRUE, level is set to seq(51,99,by=3). This is suitable for fan plots.
x Deprecated. Included for backwards compatibility.

Details

The theta method of Assimakopoulos and Nikolopoulos (2000) is equivalent to simple exponential smoothing with drift. This is demonstrated in Hyndman and Billah (2003).

The series is tested for seasonality using the test outlined in A&N. If deemed seasonal, the series is seasonally adjusted using a classical multiplicative decomposition before applying the theta method. The resulting forecasts are then reseasonalized.

Prediction intervals are computed using the underlying state space model.

More general theta methods are available in the forecTheta package.

Value

An object of class "forecast".

The function summary is used to obtain and print a summary of the results, while the function plot produces a plot of the forecasts and prediction intervals.

The generic accessor functions fitted.values and residuals extract useful features of the value returned by thetaf.

An object of class "forecast" is a list containing at least the following elements:

model A list containing information about the fitted model
method The name of the forecasting method as a character string
mean Point forecasts as a time series
lower Lower limits for prediction intervals
upper Upper limits for prediction intervals
level The confidence values associated with the prediction intervals
x The original time series (either object itself or the time series used to create the model stored as object).
residuals Residuals from the fitted model. That is x minus fitted values.
fitted Fitted values (one-step forecasts)
tsclean

Identify and replace outliers and missing values in a time series

Description

Uses supsmu for non-seasonal series and a robust STL decomposition for seasonal series. To estimate missing values and outlier replacements, linear interpolation is used on the (possibly seasonally adjusted) series.

Usage

tsclean(x, replace.missing = TRUE, lambda = NULL)

Arguments

- **x**: time series
- **replace.missing**: If TRUE, it not only replaces outliers, but also interpolates missing values
- **lambda**: Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.

Value

Time series

Author(s)

Rob J Hyndman
See Also

na.interp, tsoutliers, supsmu

Examples

cleangold <- tsClean(gold)

### tsCV

**Time series cross-validation**

#### Description

`tsCV` computes the forecast errors obtained by applying `forecastfunction` to subsets of the time series `y` using a rolling forecast origin.

#### Usage

```
tsCV(y, forecastfunction, h = 1, window = NULL, xreg = NULL, initial = 0, ...)
```

#### Arguments

- **y**: Univariate time series
- **forecastfunction**: Function to return an object of class `forecast`. Its first argument must be a univariate time series, and it must have an argument `h` for the forecast horizon. If exogenous predictors are used, then it must also have `xreg` and `newxreg` arguments corresponding to the training and test periods.
- **h**: Forecast horizon
- **window**: Length of the rolling window, if NULL, a rolling window will not be used.
- **xreg**: Exogeneous predictor variables passed to the forecast function if required.
- **initial**: Initial period of the time series where no cross-validation is performed.
- **...**: Other arguments are passed to `forecastfunction`.

#### Details

Let `y` contain the time series `y_1, \ldots, y_T`. Then `forecastfunction` is applied successively to the time series `y_1, \ldots, y_t`, for `t = 1, \ldots, T - h`, making predictions `\hat{y}_{t+h|t}`. The errors are given by `e_{t+h} = y_{t+h} - \hat{y}_{t+h|t}`. If `h=1`, these are returned as a vector, `e_1, \ldots, e_T`. For `h>1`, they are returned as a matrix with the `h`th column containing errors for forecast horizon `h`. The first few errors may be missing as it may not be possible to apply `forecastfunction` to very short time series.
Value

Numerical time series object containing the forecast errors as a vector (if h=1) and a matrix otherwise. The time index corresponds to the last period of the training data. The columns correspond to the forecast horizons.

Author(s)

Rob J Hyndman

See Also


Examples

# Fit an AR(2) model to each rolling origin subset
far2 <- function(x, h){forecast(Arima(x, order=c(2,0,0)), h=h)}
e <- tsCV(lynx, far2, h=1)

# Fit the same model with a rolling window of length 30
e <- tsCV(lynx, far2, h=1, window=30)

# Example with exogenous predictors
far2_xreg <- function(x, h, xreg, newxreg) {
  forecast(Arima(x, order=c(2,0,0), xreg=xreg), xreg=newxreg)
}
y <- ts(rnorm(50))
xreg <- matrix(rnorm(100),ncol=2)
e <- tsCV(y, far2_xreg, h=3, xreg=xreg)

tslm

Fit a linear model with time series components

Description

tslm is used to fit linear models to time series including trend and seasonality components.

Usage

tslm(formula, data, subset, lambda = NULL, biasadj = FALSE, ...)


Arguments

formula an object of class "formula" (or one that can be coerced to that class): a symbolic description of the model to be fitted.

data an optional data frame, list or environment (or object coercible by as.data.frame to a data frame) containing the variables in the model. If not found in data, the variables are taken from environment(formula), typically the environment from which lm is called.

subset an optional subset containing rows of data to keep. For best results, pass a logical vector of rows to keep. Also supports subset() functions.

lambda Box-Cox transformation parameter. If lambda="auto", then a transformation is automatically selected using BoxCox.lambda. The transformation is ignored if NULL. Otherwise, data transformed before model is estimated.

biasadj Use adjusted back-transformed mean for Box-Cox transformations. If transformed data is used to produce forecasts and fitted values, a regular back transformation will result in median forecasts. If biasadj is TRUE, an adjustment will be made to produce mean forecasts and fitted values.

... Other arguments passed to lm()

Details

tslm is largely a wrapper for lm() except that it allows variables "trend" and "season" which are created on the fly from the time series characteristics of the data. The variable "trend" is a simple time trend and "season" is a factor indicating the season (e.g., the month or the quarter depending on the frequency of the data).

Value

Returns an object of class "lm".

Author(s)

Mitchell O’Hara-Wild and Rob J Hyndman

See Also

forecast.lm, lm.

Examples

y <- ts(rnorm(120,0,3) + 1:120 + 20*sin(2*pi*(1:120)/12), frequency=12)
fit <- tslm(y ~ trend + season)
plot(forecast(fit, h=20))
Identify and replace outliers in a time series

Description

Uses supsmu for non-seasonal series and a periodic stl decomposition with seasonal series to identify outliers and estimate their replacements.

Usage

`tsoutliers(x, iterate = 2, lambda = NULL)`

Arguments

- `x` time series
- `iterate` the number of iteration only for non-seasonal series
- `lambda` Box-Cox transformation parameter. If `lambda = "auto"`, then a transformation is automatically selected using `BoxCox.lambda`. The transformation is ignored if `NULL`. Otherwise, data transformed before model is estimated.

Value

- `index` Indicating the index of outlier(s)
- `replacement` Suggested numeric values to replace identified outliers

Author(s)

Rob J Hyndman

See Also

`na.interp`, `tsclean`

Examples

```r
data(gold)
nsoutliers(gold)
```
**wineind**

*Australian total wine sales*

**Description**


**Usage**

wineind

**Format**

Time series data

**Source**

Time Series Data Library. [https://pkg.yangzhuoranyang.com/tsdl/](https://pkg.yangzhuoranyang.com/tsdl/)

**Examples**

```r
tsdisplay(wineind)
```

---

**woolyrnq**

*Quarterly production of woollen yarn in Australia*

**Description**


**Usage**

woolyrnq

**Format**

Time series data

**Source**

Time Series Data Library. [https://pkg.yangzhuoranyang.com/tsdl/](https://pkg.yangzhuoranyang.com/tsdl/)

**Examples**

```r
tsdisplay(woolyrnq)
```
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