Package 'dlmwwbe'

July 22, 2025

Title Dynamic Linear Model for Wastewater-Based Epidemiology

Version 0.1.0

Description
Implement dynamic linear models outlined in Shumway and Stoffer (2025) <doi:10.1007/978-3-031-70584-7>. Two model structures for data smoothing and forecasting are considered. The specific models proposed will be added once the manuscript is published.

License GPL (>= 3)

Encoding UTF-8

LazyData true

RoxygenNote 7.3.2

Imports dlm

Suggests knitr, rmarkdown

VignetteBuilder knitr

NeedsCompilation no

Author Difan Ouyang [aut, cre],
Lappui Chung [aut],
Charles Doss [aut]

Maintainer Difan Ouyang <ouyan146@umn.edu>

Depends R (>= 3.5.0)

Repository CRAN

Date/Publication 2025-05-26 13:10:05 UTC

Contents

`dllm` *Fit a Dynamic Local Level Model (DLM)*

Description

Fits a dynamic linear model (DLM) using maximum likelihood estimation.

Usage

```
dllm(
  data,
  obs_cols,
  S = c("univariate", "kvariate"),
  log10 = FALSE,
  date = NULL,
  prior = list(),
  equal.state.var = FALSE,
  equal.obs.var = FALSE,
  init_params = NULL,
  auto_init = TRUE,
  control = list(maxit = 500)
)
```

Arguments

`data`	A data frame containing observed time series data.
`obs_cols`	Character vector of column names in `data` to be used as observations.
`S`	Character; the structure of latent states.
`log10`	logical; if TRUE, a log10 transformation is applied to the whole data.
`date`	Optional; the name of the column in `data` representing date or time.
`prior`	A list of prior specifications. Default priors are used if not supplied.
`equal.state.var`	logical; if TRUE the variance is the same across all wastewater state.
`equal.obs.var`	logical; if TRUE the variance is the same across all wastewater observation.
`init_params`	Optional numeric vector of initial parameters.
`auto_init`	Logical; if `TRUE` (default) and `init_params` is `NULL`, initial parameters are estimated automatically.
`control`	List of control parameters for the optimization routine (`dlmMLE`).

Details

The function prepares the data, validates inputs, and (if necessary) automatically initializes parameters. It then defines a helper function to build the model via `build_dlm` and fits the model using maximum likelihood estimation (`dlmMLE`). Filtering and smoothing are applied to obtain state estimates.

Value

An object of class `dllm` containing the fitted model, filtered and smoothed estimates, along with fit statistics (log-likelihood, AIC, BIC) and other diagnostic information.

data The input data.

date The input vector of date.

obs_cols Character vector of column names in `data` to be used as observations.

S Character; the structure of latent states.

parameters A list of estimated parameters by maximum likelihood estimation.

logLik The loglikelihood of the fitted model.

aic AIC of the fitted model.

bic BIC of the fitted model.

convergence An integer code returned by `optim`

model An `dlm` object of the fitted dynamic linear model.

filter The corresponding dynamic linear filter returned by `dlmFilter`

smoother The corresponding dynamic linear smoother returned by `dlmSmooth`

yf A matrix of the filtered observed response variables.

ys A matrix of the smoothed observed response variables.

Examples

```
data<- wastewater[wastewater$Code == "TC",]
data$SampleDate <- as.Date(data$SampleDate)
fit <- dllm(
equal.state.var=TRUE,
equal.obs.var=FALSE,
log10=TRUE,
data = data,
date = "SampleDate",
obs_cols = c("ORFlab", "Nlab"),
S = 'kvariate')
summary(fit)
plot(fit, type='smoother', plot_data = TRUE)
```

`pdlm` *Build a Predictive Dynamic Linear Model (pdlm) for wastewater-based epidemiology*

Description

Constructs a dynamic linear model (DLM) object using the **dlm** package.

Usage

```
pdlm(
  data,
  formula,
  lags = 0,
  log10 = TRUE,
  date = NULL,
  prior = list(),
  equal.state.var = TRUE,
  equal.obs.var = TRUE,
  init_params = list(),
  auto_init = TRUE,
  control = list(maxit = 500)
)
```

Arguments

`data`	A data frame containing the variables in the model.
`formula`	An object of class "formula" describing the model to be fitted.
`lags`	A nonnegative integer indicating the lag of the latent state in the model.
`log10`	Logical; if TRUE, a log10 transformation is applied to the entire dataset.
`date`	An optional vector of date indices of the data.
`prior`	An optional list specifying the prior mean vector and covariance structure of the latent state. If not provided, a naive prior is used.
`equal.state.var`	Logical; if TRUE, the same variance is assumed across all state components.
`equal.obs.var`	Logical; if TRUE, the same variance is assumed across all observation components.
`init_params`	An optional list of initial parameters for the model. Should include Ft, Wt, and Vt: transition coefficients, state variance, and observation variance components respectively.
`auto_init`	Logical; if TRUE, naive initial parameters are used.
`control`	An optional list of control parameters for `optim()`.

Value

A `dlm` object with additional attributes:

formula The fitted formula.

lags Number of lags.

data The input data.

date The input vector of dates.

parameters A list of estimated parameters.

logLik Log-likelihood of the fitted model.

aic Akaike Information Criterion.

bic Bayesian Information Criterion.

convergence The convergence code from `optim`.

model The final `dlm` object.

filter Output from `dlmFilter`.

ypred One-step-ahead predictions.

var.pred Variance of the predictions.

Examples

```
data <- wastewaterhealthworker[wastewaterhealthworker$Code == "TC",]
data$SampleDate <- as.Date(data$SampleDate)
fit <- pdlm(
  formula=HealthWorkerCaseCount~WW.tuesday+WW.thursday,
  data = data,
  lags = 2,
  equal.state.var=FALSE,
  equal.obs.var=FALSE,
  log10=TRUE,
  date = "SampleDate")
summary(fit)
plot(fit, conf.int = TRUE)
```

`plot.dllm` *Plot a Fitted Dynamic Local Level Model*

Description

Produces a plot for an object of class `dllm` (typically created by `dllm`). The function displays the observed data along with the fitted curves computed using filtered and/or smoothed state estimates.

Usage

```
## S3 method for class 'dllm'
plot(
  x,
  type = c("smoother", "filter"),
  plot_data = TRUE,
  obs_cols = NULL,
  obs_colors = NULL,
  filter_colors = NULL,
  smoother_colors = NULL,
  conf.int = FALSE,
  sig.level = 0.95,
  ...
)
```

Arguments

x	An object of class dllm, as returned by dlm.
type	Character; one of "smoother" or "filter" (default: "smoother"). Specifies which fitted curves to display.
plot_data	Logical; if TRUE (default) the observed data points are plotted.
obs_cols	Character; an optional argument specifying the variables to be plotted. If NULL, plot all variables.
obs_colors	Optional character vector specifying custom colors for observed data. If not supplied, a default palette is used.
filter_colors	Optional character vector specifying custom colors for filtered curves. If not supplied, a default palette is used.
smoother_colors	Optional character vector specifying custom colors for smoothed curves. If not supplied, a default palette is used.
conf.int	Logical; if TRUE, plot confidence intervals with the given sig.level.
sig.level	Numeric; significance level for confidence intervals (default: 0.95).
...	Additional graphical parameters to pass to the underlying plotting functions.

Value

This function produces a plot of the fitted DLM and returns NULL invisibly.

---

plot.pdlm *Plot a Fitted Predictive Dynamic Linear Model*

Description

Produces a plot for an object of class pdlm (typically created by pdlm). The function displays the observed data along with the fitted curves computed using filtered and/or smoothed state estimates.

Usage

```
## S3 method for class 'pdlm'
plot(x, plot_data = TRUE, conf.int = FALSE, sig.level = 0.95, ...)
```

Arguments

x	An object of class pdlm, as returned by dlm.
plot_data	Logical; if TRUE (default) the observed data points are plotted.
conf.int	Logical; if TRUE, plot confidence intervals with the given sig.level.
sig.level	Numeric; significance level for confidence intervals (default: 0.95).
...	Additional graphical parameters to pass to the underlying plotting functions.

Value

This function produces a plot of the fitted DLM and returns NULL invisibly.

summary.dllm *Summarize a fitted Dynamic Local Level Model object*

Description

Provides a brief summary of the fitted dynamic local level model, including parameter estimates and log-likelihood.

Usage

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

Arguments

object	An object of class dllm, as returned by dllm.
...	Additional arguments (not used).

Value

The object is returned invisibly.

summary.pdlm *Summarize a fitted Predictive Dynamic Linear object*

Description

Provides a brief summary of the fitted predictive dynamic linear model, including parameter estimates and log-likelihood.

Usage

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

Arguments

object	An object of class pdlm, as returned by pdlm.
...	Additional arguments (not used).

Value

The object is returned invisibly.

wastewater *Dataset wastewater:*

Description

A dataset containing the long format of daily wastewater data collected in Minnesota from March 2022 to February 2023. The wastewater was collected twice a week with possible missing values.

Usage

```
wastewater
```

Format

A data frame with 1348 rows and 4 variables:

Code Character. The code name of the treatment plant where the wastewater was sampled.

SampleDate Date. The sample collection date.

ORFlab The ORF target.

Nlab The N target.

wastewaterhealthworker *Dataset wastewaterhealthworker:*

Description

A dataset containing the wide format of weekly wastewater and clinical case data collected in Minnesota from March 2022 to Feburary 2023. The wastewater was collected twice a week with possible missing values.

Usage

```
wastewaterhealthworker
```

Format

A data frame with 196 rows and 5 variables:

Code Character. The code name of the treatment plant where the wastewater was sampled.

SampleDate Date. The sample collection date.

HealthWorkerCaseCount Integer. Reported weekly Covid-19 positive case counts.

WW.tuesday Flow adjusted wastewater measurement from Tuesday samples.

WW.thursday Flow adjusted wastewater measurement from Thursday samples.

Index