

Package ‘ltvlms’

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Type Package

Title Linear Time-Variant Logistic Models with a Shape Parameter

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Description Evaluates and fits the Linear Time-Variant Logistic Model with Shape Parameter (LTVLMS) for dynamic growth processes. The model combines a linearly time-varying growth rate with a shape parameter for asymmetric trajectories and includes numerically stable prediction utilities. Methodological details are provided by Betrouni and Kernane (2026) ``Linear Time-Varying Logistic Model With Shape Parameter for Dynamic Epidemic Modeling" <[doi:10.1155/jama/4928447](https://doi.org/10.1155/jama/4928447)>.

Depends R (>= 4.0.0)

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ltvlms-package	<i>Linear Time-Variant Logistic Models with a Shape Parameter</i>
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Description

Tools to evaluate, fit, compare, and validate Logistic, Gompertz, Richards, and Linear Time-Variant Logistic Models with a Shape Parameter. Fitting uses bounded multi-start optimization initialized by Latin hypercube sampling.

Details

Start with `fit_growth_model()` for a single model or `compare_growth_models()` for all four models. Use `cross_validate_growth()` to distinguish random interpolation assessment from forward-in-time forecasting assessment.

compare_growth_models	<i>Compare Growth Models</i>
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Description

Fits multiple models under the same workflow and reports consistently computed performance metrics. Failed models remain visible rather than being discarded.

Usage

```
compare_growth_models(time, response,
  models = c("logistic", "gompertz", "richards", "ltvlms"),
  n_starts = 50L, seed = 42, bounds = NULL,
  convention = c("standard", "paper"))

## S3 method for class 'growth_comparison'
print(x, ...)
## S3 method for class 'growth_comparison'
plot(x, ..., xlab = "Time", ylab = "Response")
```

Arguments

time	Numeric observation times.
response	Positive numeric observations.
models	Character vector of model names.
n_starts	Number of multi-start attempts per model.
seed	Seed for reproducible starting points.
bounds	Optional named list of model-specific bound lists.
convention	Information-criterion convention.
x	A growth_comparison object.
xlab, ylab	Plot axis labels.
...	Additional graphical arguments.

Value

An object containing successful fits, metrics, and failure messages.

cross_validate_growth *Cross-Validate a Growth Model*

Description

Random folds assess interpolation similarly to the manuscript. Forward folds train only on earlier observations and assess forecasting of later observations.

Usage

```
cross_validate_growth(time, response,
  model = c("ltvlms", "logistic", "gompertz", "richards"),
  folds = 5L, method = c("random", "forward"),
  n_starts = 20L, seed = 42, bounds = NULL)

## S3 method for class 'growth_cv'
print(x, ...)
```

Arguments

time	Numeric observation times.
response	Positive numeric observations.
model	Growth model name.
folds	Number of validation folds.
method	Random interpolation folds or forward forecasting folds.
n_starts	Multi-start attempts per training fold.

seed	Seed for folds and starting values.
bounds	Optional parameter bounds.
x	A growth_cv object.
...	Additional arguments reserved for methods.

Value

An object containing fold results, predictions, fitted models, and mean errors.

fit_growth_model	<i>Fit a Nonlinear Growth Model</i>
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Description

Fits a growth model using bounded PORT optimization from multiple Latin hypercube starting values. Failed starts are retained in the convergence count rather than silently treated as successful.

Usage

```
fit_growth_model(
  time,
  response,
  model = c("ltvlms", "logistic", "gompertz", "richards"),
  n_starts = 50L,
  bounds = NULL,
  seed = 42,
  control = list(iter.max = 10000L, eval.max = 20000L)
)
```

Arguments

time	Finite numeric observation times.
response	Finite positive observed responses.
model	Name of the growth model to fit.
n_starts	Number of Latin hypercube starting points.
bounds	Optional named list of lower and upper parameter bounds.
seed	Seed used to generate starting points.
control	Control list passed to nlminb.

Value

An object of class growth_fit.

Examples

```
time <- 0:12
response <- logistic_growth(time, K = 20, r = 0.4, y0 = 1)
fit <- fit_growth_model(time, response, model = "logistic", n_starts = 5)
fit
```

growth_curves

*Evaluate Growth Curves***Description**

Evaluates the logistic, Gompertz, Richards, or Linear Time-Variant Logistic Model with Shape Parameter using numerically stable calculations.

Usage

```
logistic_growth(t, K, r, y0)

gomperztz_growth(t, K, r, t0)

richards_growth(t, K, r, t0, alpha, nu)

ltvlms(t, K, y0, r0, r1 = 0, nu = 1)
```

Arguments

t	Numeric vector of time points measured from the model origin.
K	Positive carrying capacity.
r	Positive constant growth rate.
y0	Positive initial response at time zero, not exceeding K.
t0	Location parameter for the Gompertz or Richards curve.
alpha	Positive Richards scale parameter.
nu	Positive shape parameter.
r0	Initial LTVLMS growth rate.
r1	Linear change in the LTVLMS growth rate.

Value

A numeric vector with the same length as t.

Examples

```
time <- 0:10
ltvlms(time, K = 100, y0 = 2, r0 = 0.5, r1 = -0.02, nu = 1.2)
logistic_growth(time, K = 100, r = 0.5, y0 = 2)
```

Description

Extract coefficients, fitted values, and residuals; predict, print, or plot a fitted growth model.

Usage

```
## S3 method for class 'growth_fit'
coef(object, ...)
## S3 method for class 'growth_fit'
fitted(object, ...)
## S3 method for class 'growth_fit'
residuals(object, ...)
## S3 method for class 'growth_fit'
predict(object, newdata = NULL, ...)
## S3 method for class 'growth_fit'
print(x, ...)
## S3 method for class 'growth_fit'
plot(x, ..., xlab = "Time", ylab = "Response")
```

Arguments

object, x	A growth_fit object.
newdata	Optional numeric vector of new time values.
xlab, ylab	Plot axis labels.
...	Additional arguments, including graphical parameters for plotting.

Value

The return value depends on the method:

- `coef` returns a named numeric vector containing the estimated model parameters.
- `fitted` returns a numeric vector of fitted responses at the observed time values.
- `residuals` returns a numeric vector of observed responses minus their fitted values.
- `predict` returns a numeric vector of fitted responses when `newdata` is `NULL`, or predictions at the supplied time values otherwise.
- `print` invisibly returns the original `growth_fit` object after displaying a summary of the fit.
- `plot` invisibly returns the original `growth_fit` object after drawing the observations and fitted curve.

growth_metrics	<i>Growth Model Performance Metrics</i>
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Description

Calculates prediction metrics and consistently defined information criteria.

Usage

```
growth_metrics(observed, predicted, n_parameters,
               convention = c("standard", "paper"))

metrics(object, convention = c("standard", "paper"), ...)

## S3 method for class 'growth_fit'
metrics(object,
        convention = c("standard", "paper"), ...)
```

Arguments

observed	Numeric observed values.
predicted	Numeric predicted values.
n_parameters	Number of fitted curve parameters, excluding variance.
convention	Information-criterion convention. Use "paper" for the constant-free least-squares formulas used for manuscript-comparison reporting.
object	A fitted growth model.
...	Additional arguments reserved for methods.

Value

A one-row data frame containing MSE, RMSE, R-squared, AIC, BIC, and AICc.

hiv_prevalence_63	<i>Adult HIV Prevalence Estimates for 63 Countries and Regions</i>
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Description

Complete prevalence series used by the manuscript's cross-country comparison. The data contain 34 annual observations for each of 63 countries or regions.

Usage

```
data(hiv_prevalence_63)
```

Format

A data frame with 2,142 rows and 4 variables:

year Calendar year from 1990 through 2023.

code UNAIDS country or region code.

country Country or region name.

prevalence Estimated HIV prevalence percentage among adults aged 15-49.

Note

These UNAIDS-derived data are not covered by the package's MIT software license. Their use remains subject to the UNAIDS terms at <https://www.unaids.org/en/terms-of-use>.

Source

UNAIDS 2024, *HIV estimates with uncertainty bounds, 1990-2023*, as distributed with the manuscript authors' public analysis repository. Official UNAIDS dataset portal: <https://aidsinfo.unaids.org/dataset>.

south_africa_hiv	<i>South Africa Adult HIV Prevalence Estimates, 1990-2023</i>
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Description

Annual national HIV prevalence estimates used for the manuscript's South Africa case study. These are modeled UNAIDS estimates, not raw diagnosis counts.

Usage

```
data(south_africa_hiv)
```

Format

A data frame with 34 rows and 4 variables:

year Calendar year.

code UNAIDS country code, "ZAF".

country Country name.

prevalence Estimated HIV prevalence percentage among adults aged 15-49.

Note

These UNAIDS-derived data are not covered by the package's MIT software license. Their use remains subject to the UNAIDS terms at <https://www.unaids.org/en/terms-of-use>.

Source

UNAIDS 2024, *HIV estimates with uncertainty bounds, 1990-2023*, as distributed with the manuscript authors' public analysis repository. Official UNAIDS dataset portal: <https://aidsinfo.unaids.org/dataset>.

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