

Package: echos (via r-universe)

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Type Package

Title Echo State Networks for Time Series Modeling and Forecasting

Version 1.0.1

Description Provides a lightweight implementation of functions and methods for fast and fully automatic time series modeling and forecasting using Echo State Networks (ESNs).

License GPL-3

URL <https://github.com/ahaeusser/echos>,
<https://ahaeusser.github.io/echos/>

BugReports <https://github.com/ahaeusser/echos/issues>

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ESN

Automatic train an Echo State Network

Description

This function trains an Echo State Network (ESN) to a univariate time series.

Usage

```
ESN(formula, ...)
```

Arguments

`formula` Model specification (currently not in use).
`...` Further arguments passed to `train_esn()`.

Value

An object of class ESN.

Examples

```
library(tsibble)
library(fable)
AirPassengers %>%
  as_tsibble() %>%
  model("ESN" = ESN(value))
```

fitted.ESN

Extract fitted values from a trained ESN

Description

Extract fitted values from a trained ESN.

Usage

```
## S3 method for class 'ESN'
fitted(object, ...)
```

Arguments

object	An object of class ESN.
...	Currently not in use.

Value

Fitted values extracted from the object.

Examples

```
library(tsibble)
library(fable)
AirPassengers %>%
  as_tsibble() %>%
  model("ESN" = ESN(value)) %>%
  fitted()
```

forecast.ESN	<i>Forecast a trained ESN</i>
--------------	-------------------------------

Description

Forecast a trained ESN.

Usage

```
## S3 method for class 'ESN'
forecast(object, new_data, specials = NULL, xreg = NULL, ...)
```

Arguments

object	An object of class ESN.
new_data	Forecast horizon (n-step ahead forecast)
specials	Currently not in use
xreg	A tsibble containing exogenous variables.
...	Currently not in use.

Value

An object of class fable.

Examples

```
library(tsibble)
library(fable)
AirPassengers %>%
  as_tsibble() %>%
  model("ESN" = ESN(value)) %>%
  forecast(h = 18)
```

forecast_esn	<i>Forecast a trained Echo State Network</i>
--------------	--

Description

Forecast an Echo State Network from a trained model.

Usage

```
forecast_esn(object, n_ahead = 18)
```

Arguments

`object` An object of class `esn`. The result of a call to `train_esn()`.
`n_ahead` Integer value. The number of periods for forecasting (i.e. forecast horizon).

Value

A list containing:

- `point`: Numeric vector containing the point forecasts.
- `actual`: Numeric vector containing the actual values.
- `fitted`: Numeric vector containing the fitted values.
- `n_ahead`: Integer value. The number of periods for forecasting (forecast horizon).
- `model_spec`: Character value. The model specification as string.

Examples

```
xdata <- as.numeric(AirPassengers)
xmodel <- train_esn(y = xdata)
xfcst <- forecast_esn(xmodel, n_ahead = 12)
plot(xfcst)
```

`glance.ESN`

Summary of trained models during random search

Description

Return summary statistics from trained ESN models during random search as tibble.

- `model`: Model identifier.
- `loglik`: Log-likelihood.
- `nobs`: Number of observations.
- `df`: Effective degrees of freedom.
- `lambda`: Regularization parameter.
- `aic`: Akaike Information Criterion.
- `aicc`: Corrected Akaike Information Criterion.
- `bic`: Bayesian Information Criterion.
- `hqic`: Hannan-Quinn Information Criterion.
- `mse`: Mean Squared Error.
- `mae`: Mean Absolute Error.

Usage

```
## S3 method for class 'ESN'
glance(x, ...)
```

Arguments

x An object of class ESN.
... Currently not in use.

Value

Summary statistics extracted from the object.

Examples

```
library(tsibble)
library(fable)
AirPassengers %>%
as_tsibble() %>%
model("ESN" = ESN(value)) %>%
glance()
```

is.esn

Checks if object is of class "esn"

Description

Returns TRUE if the object is of class "esn".

Usage

```
is.esn(object)
```

Arguments

object object to be tested.

Value

Logical value. If TRUE, the object is of class "esn".

Examples

```
xdata <- as.numeric(AirPassengers)
xmodel <- train_esn(y = xdata)
is.esn(xmodel)
```

is.forecast_esn	<i>Checks if object is of class "forecast_esn"</i>
-----------------	--

Description

Returns TRUE if the object is of class "forecast_esn".

Usage

```
is.forecast_esn(object)
```

Arguments

object object to be tested.

Value

Logical value. If TRUE, the object is of class "forecast_esn".

Examples

```
xdata <- as.numeric(AirPassengers)
xmodel <- train_esn(y = xdata)
xfcst <- forecast_esn(xmodel, n_ahead = 12)
is.forecast_esn(xfcst)
```

m4_data	<i>M4 dataset</i>
---------	-------------------

Description

Monthly tsibble with six exemplary time series from the M4 Forecasting Competition.

Usage

```
data(m4_data)
```

Format

A time series object of class tsibble with 1.152 rows and 4 columns:

- series: Unique identifier as character (key variable).
- category: Category (e.g., Demographic, Macro) as factor.
- index: Date as yearmonth (index variable).
- value: Value as numeric (measurement variable).

Source

M4 Forecasting Competition

Examples

```
data(m4_data)
```

model_sum.ESN

Provide a succinct summary of a trained ESN

Description

Provide a succinct summary of a trained ESN.

Usage

```
## S3 method for class 'ESN'  
model_sum(x)
```

Arguments

x An object of class ESN.

Value

Model summary extracted from the object.

Examples

```
library(tsibble)  
library(fable)  
AirPassengers %>%  
as_tsibble() %>%  
model("ESN" = ESN(value))
```

plot.forecast_esn *Plot point forecasts and actuals of a trained ESN model.*

Description

Plot point forecasts and actuals of a trained ESN model as line chart. Optionally, test data (out-of-sample) can be added to the plot.

Usage

```
## S3 method for class 'forecast_esn'
plot(x, test = NULL, ...)
```

Arguments

x	An object of class forecast_esn.
test	Numeric vector. Test data, i.e., out-of-sample actual values.
...	Currently not in use.

Value

Line chart of point forecast and actual values.

Examples

```
xdata <- as.numeric(AirPassengers)
xmodel <- train_esn(y = xdata)
xfcst <- forecast_esn(xmodel, n_ahead = 12)
plot(xfcst)
```

print.esn *Print specification of the trained ESN model*

Description

Print specification of the trained ESN model.

Usage

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

Arguments

x	An object of class esn.
...	Currently not in use.

Value

Print specification of the trained ESN model.

Examples

```
xdata <- as.numeric(AirPassengers)
xmodel <- train_esn(y = xdata)
print(xmodel)
```

report.ESN

Provide a detailed summary of the trained ESN model

Description

Provide a detailed summary of the trained ESN model.

Usage

```
## S3 method for class 'ESN'
report(object, ...)
```

Arguments

object	An object of class ESN.
...	Currently not in use.

Value

Print detailed model summary.

Examples

```
library(tsibble)
library(fable)
AirPassengers %>%
  as_tsibble() %>%
  model("ESN" = ESN(value)) %>%
  report()
```

reservoir	<i>Return the reservoir from a trained ESN as tibble</i>
-----------	--

Description

Return the reservoir (internal states) from a trained ESN as tibble. The function works only for models of class ESN.

Usage

```
reservoir(object)
```

Arguments

object An object of class ESN.

Value

A tibble containing the reservoir (internal states).

Examples

```
library(tsibble)
library(fable)
AirPassengers %>%
  as_tsibble() %>%
  model("ESN" = ESN(value)) %>%
  reservoir()
```

residuals.ESN	<i>Extract residuals from a trained ESN</i>
---------------	---

Description

Extract residuals from a trained ESN.

Usage

```
## S3 method for class 'ESN'
residuals(object, ...)
```

Arguments

object An object of class ESN.
 ... Currently not in use.

Value

Residuals extracted from the object.

Examples

```
library(tsibble)
library(fable)
AirPassengers %>%
  as_tsibble() %>%
  model("ESN" = ESN(value)) %>%
  residuals()
```

run_reservoir

Run reservoir

Description

Run reservoir creates the internal states for the ESN.

Arguments

input	Numeric matrix containing the input features
win	Numeric matrix. The input weight matrix.
wres	Numeric matrix. The reservoir weight matrix.
alpha	Numeric value. The leakage rate (smoothing parameter).

Value

states train Numeric matrix with the internal states.

summary.esn

Provide a detailed summary of the trained ESN model

Description

Provide a detailed summary of the trained ESN model.

Usage

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

Arguments

object An object of class esn.
 ... Currently not in use.

Value

Print detailed model summary.

Examples

```
xdata <- as.numeric(AirPassengers)
xmodel <- train_esn(y = xdata)
summary(xmodel)
```

tidy.ESN	<i>Estimated coefficients</i>
----------	-------------------------------

Description

Return the estimated coefficients from a trained ESN as tibble.

Usage

```
## S3 method for class 'ESN'
tidy(x, ...)
```

Arguments

x An object of class ESN.
 ... Currently not in use.

Value

Coefficients extracted from the object.

Examples

```
library(tsibble)
library(fable)
AirPassengers %>%
  as_tsibble() %>%
  model("ESN" = ESN(value)) %>%
  tidy()
```

train_esn

*Train an Echo State Network***Description**

This function trains an Echo State Network (ESN) to a univariate time series.

Usage

```
train_esn(
  y,
  lags = 1,
  inf_crit = "bic",
  n_diff = NULL,
  n_states = NULL,
  n_models = NULL,
  n_initial = NULL,
  n_seed = 42,
  alpha = 1,
  rho = 1,
  density = 0.5,
  lambda = c(1e-04, 2),
  scale_win = 0.5,
  scale_wres = 0.5,
  scale_inputs = c(-0.5, 0.5)
)
```

Arguments

y	Numeric vector containing the response variable.
lags	Integer vectors with the lags associated with the input variable.
inf_crit	Character value. The information criterion used for variable selection <code>inf_crit = c("aic", "aicc", "bic")</code> .
n_diff	Integer vector. The nth-differences of the response variable.
n_states	Integer value. The number of internal states per reservoir.
n_models	Integer value. The maximum number of (random) models to train for model selection.
n_initial	Integer value. The number of observations of internal states for initial drop out (throw-off).
n_seed	Integer value. The seed for the random number generator (for reproducibility).
alpha	Numeric value. The leakage rate (smoothing parameter) applied to the reservoir.
rho	Numeric value. The spectral radius for scaling the reservoir weight matrix.
density	Numeric value. The connectivity of the reservoir weight matrix (dense or sparse).

lambda	Numeric vector. Lower and upper bound of lambda sequence for ridge regression.
scale_win	Numeric value. The lower and upper bound of the uniform distribution for scaling the input weight matrix.
scale_wres	Numeric value. The lower and upper bound of the uniform distribution for scaling the reservoir weight matrix.
scale_inputs	Numeric vector. The lower and upper bound for scaling the time series data.

Value

A list containing:

- actual: Numeric vector containing the actual values.
- fitted: Numeric vector containing the fitted values.
- resid: Numeric vector containing the residuals.
- states_train: Numeric matrix containing the internal states.
- method: A list containing several objects and meta information of the trained ESN (weight matrices, hyperparameters, model metrics, etc.).

Examples

```
xdata <- as.numeric(AirPassengers)
xmodel <- train_esn(y = xdata)
summary(xmodel)
```

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