Package ‘echos’

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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).

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

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

Depends R (>= 4.0.0)

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Repository CRAN

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Contents

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` *Forecast a trained ESN*

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` *Forecast a trained Echo State Network*

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.
- `hqc`: 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` *Checks if object is of class "forecast_esn"*

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` *M4 dataset*

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` *Return the reservoir from a trained ESN as tibble*

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` *Extract residuals from a trained ESN*

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` *Estimated coefficients*

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 `inf_crit = c("aic", "aicc", "bic")`.
`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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