CRAN Task View: Time Series Analysis

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Version:	2025-05-17
URL:	https://CRAN.R-project.org/view=TimeSeries
Source:	https://github.com/cran-task-views/TimeSeries/
Contributions:	Suggestions and improvements for this task view are very welcome and can be made through issues or pull requests on GitHub or via e-mail to the maintainer address. For further details see the Contributing guide.
Citation:	Rob J Hyndman, Rebecca Killick (2025). CRAN Task View: Time Series Analysis. Version 2025-05-17. URL https://CRAN.R-project.org/view=TimeSeries.
Installation:	The packages from this task view can be installed automatically using the ctv package. For example, `ctv::install.views("TimeSeries", coreOnly = TRUE)` installs all the core packages or `ctv::update.views("TimeSeries")` installs all packages that are not yet installed and up-to-date. See the CRAN Task View Initiative for more details.

Base R ships with a lot of functionality useful for time series, in particular in the stats package. This is complemented by many packages on CRAN, which are briefly summarized below. There is overlap between the tools for time series and those designed for specific domains including Econometrics, Finance and Environmetrics.

The packages in this view can be roughly structured into the following topics. If you think that some package is missing from the list, please let us know, either via e-mail to the maintainer or by submitting an issue or pull request in the GitHub repository linked above.

Basics

- *Infrastructure* : Base R contains substantial infrastructure for representing and analysing time series data. The fundamental class is `"ts"` that can represent regularly spaced time series (using numeric time stamps). Hence, it is particularly well-suited for annual, monthly, quarterly data, etc.
- *Rolling statistics* : Moving averages are computed by `ma` from forecast, and `rollmean` from zoo. The latter also provides a general function `rollapply`, along with other specific rolling statistics functions. slider calculates a diverse and comprehensive set of type-stable running functions for any R data types. tsibble provides `slide_tsibble()` for rolling statistics, `tile_tsibble()` for non-overlapping sliding windows, and `stretch_tsibble()` for expanding windows. tbrf provides rolling functions based on date and time windows instead of n-lagged observations. roll provides fast and efficient computation of rolling and expanding statistics for time-series data using online algorithms and parallelized C++ code with support for weights and missing values. runner provides tools for running any R function in rolling windows or date windows. runstats provides fast computational methods for some running sample statistics. For data.table, `froll()` can be used for high-performance rolling statistics.
- *Graphics* : Time series plots are obtained with `plot()` applied to `ts` objects. (Partial) autocorrelation functions plots are implemented in `acf()` and `pacf()`. Alternative versions are provided by `Acf()` and `Pacf()` in forecast, along with a combination display using `tsdisplay()`. Seasonal displays are obtained using `monthplot()` in stats, `seasonplot` in forecast, and `seasplot` in tsutils. feasts provides various time series graphics for tsibble objects including time plots, season plots, subseries plots, ACF and PACF plots, and some combination displays. Interactive graphics for tsibbles using htmlwidgets are

provided by tsibbletalk. dCovTS computes and plots the distance covariance and correlation functions of time series. ggseas provides additional ggplot2 graphics for seasonally adjusted series and rolling statistics. gglinedensity provides a ggplot2 statistic for DenseLines heatmaps of time series normalized by arc length. Calendar plots are implemented in sugrrants. gravitas allows for visualizing probability distributions conditional on bivariate temporal granularities. dygraphs provides an interface to the Dygraphs interactive time series charting library. Alternative interactive time series visualizations using the vis.js Timeline library are provided by linevis. TSstudio also provides some interactive visualization tools for time series. ZRA plots forecast objects from the forecast package using dygraphs. Basic fan plots of forecast distributions are provided by forecast and vars. More flexible fan plots of any sequential distributions are implemented in fanplot.

Times and Dates

- Class `"ts"` can only deal with numeric time stamps, but many more classes are available for storing time/date information and computing with it. For an overview see *R Help Desk: Date and Time Classes in R* by Gabor Grothendieck and Thomas Petzoldt in R News 4(1), 29-32.
- Classes `"yearmon"` and `"yearqtr"` from zoo allow for more convenient computation with monthly and quarterly observations, respectively.
- Class `"Date"` from the base package is the basic class for dealing with dates in daily data. The dates are internally stored as the number of days since 1970-01-01.
- The chron package provides classes for `dates()`, `hours()` and date/time (intraday) in `chron()`. There is no support for time zones and daylight savings time. Internally, `"chron"` objects are (fractional) days since 1970-01-01.
- Classes `"POSIXct"` and `"POSIXlt"` implement the POSIX standard for date/time (intraday) information and also support time zones and daylight savings time. However, the time zone computations require some care and might be system-dependent. Internally, `"POSIXct"` objects are the number of seconds since 1970-01-01 00:00:00 GMT. Package lubridate provides functions that facilitate certain POSIX-based computations, while clock provides a comprehensive library for date-time manipulations using a new family of orthogonal date-time classes (durations, time points, zoned-times, and calendars). The anytime package converts various inputs into `POSIXct` or `Date` objects. Various recurrent calendar calculations are possibly using almanac. timechange allows for efficient manipulation of date-times accounting for time zones and daylight saving times. wktmo converts weekly data to monthly data in several ways.
- Class `"timeDate"` is provided in the timeDate package (previously: fCalendar). It is aimed at financial time/date information and deals with time zones and daylight savings times via a new concept of “financial centers”. Internally, it stores all information in `"POSIXct"` and does all computations in GMT only. Calendar functionality, e.g., including information about weekends and holidays for various stock exchanges, is also included. qlcal allows access to various financial exchange calendars via QuantLib.
- parttime provides date time classes that allow for uncertainty and partially missing information.
- Datetimes with optional UTC offsets and/or heterogeneous time zones are provided by datetimeoffset.
- To convert between the Gregorian and the Vedic calendars, use VedicDateTime, while jalcal provides conversions between the Gregorian and Persian Jalali (or Solar Hijri) calendars. For year-based time series, era provides for many year numbering systems used in contemporary and historic calendars (e.g. Common Era, Islamic ‘Hijri’ years), as well as year-based time scales used in archaeology, astronomy, geology, and other palaeosciences. aion contains a toolkit for handling archaeological time series.

- The tis package provides the `"ti"` class for time/date information.
- The `"mondate"` class from the mondate package facilitates computing with dates in terms of months.
- The CFtime package encapsulates the CF Metadata Conventions “time” dimension, including all defined calendars. It facilitates the processing of climate change projection data.
- The tempdisagg package includes methods for temporal disaggregation and interpolation of a low frequency time series to a higher frequency series. Time series disaggregation is also provided by TSdisaggregation, tsdisagg2 and disaggR.

Time Series Classes

- As mentioned above, `"ts"` is the basic class for regularly spaced time series using numeric time stamps.
- The zoo package provides infrastructure for regularly and irregularly spaced time series using arbitrary classes for the time stamps (i.e., allowing all classes from the previous section). It is designed to be as consistent as possible with `"ts"`.
- The package xts is based on zoo and provides uniform handling of R’s different time-based data classes.
- Several packages aim to handle time-based tibbles: tsibble provides tidy temporal data frames and associated tools; tsbox contains tools for working with and coercing between many time series classes including tsibble, ts, xts, zoo and more. timetk is another toolkit for converting between various time series data classes.
- Some manipulation tools for time series are available in data.table including `shift()` for lead/lag operations. Further basic time series functionalities are offered by DTSg which is based on data.table. dtts provides high-frequency time series support via nanotime and data.table.
- collapse provides fast computation of several time series functions such as lead/lag operations, (quasi-, log-) differences and growth rates on time-series and panel data, and ACF/PACF/CCF estimation for panel data.
- Various packages implement irregular time series based on `"POSIXct"` time stamps, intended especially for financial applications. These include `"irts"` from tseries.
- The class `"timeSeries"` in timeSeries (previously: fSeries) implements time series with `"timeDate"` time stamps.
- The class `"tis"` in tis implements time series with `"ti"` time stamps.
- The package tframe contains infrastructure for setting time frames in different formats.
- timeseriesdb manages time series for official statistics by mapping `ts` objects to PostgreSQL relations.

Forecasting and Univariate Modeling

- The fable package provides tools for fitting univariate time series models to many series simultaneously including ETS, ARIMA, TSLM and other models. It also provides many functions for computing and analysing forecasts. The time series must be in the `tsibble` format. fabletools provides tools for extending the fable framework.
- The forecast package provides similar tools for `ts` objects, while modeltime provides time series forecasting tools for use with the ‘tidymodels’ ecosystem. Forecast resampling tools for use with `modeltime` are provided by modeltime.resample.
- *Exponential smoothing* : `HoltWinters()` in stats provides some basic models with partial optimization, `ETS()` from fable and `ets()` from forecast provide a larger set of models and facilities with full optimization. smooth implements some generalizations of exponential smoothing. legion implements multivariate versions of exponential smoothing. The MAPA package combines exponential smoothing models at different levels of temporal aggregation to improve forecast accuracy. Some Bayesian extensions of exponential

smoothing are contained in Rlgt.
- TBATS models are available in forecast and tsissm.
- prophet forecasts time series based on an additive model where nonlinear trends are fit with yearly and weekly seasonality, plus holidays. It works best with daily data. fable.prophet allows prophet models to be used in the fable framework.
- The theta method is implemented in the `THETA()` function from fable, `thetaf()` function from forecast, and `theta()` from tsutils. An alternative and extended implementation is provided in forecTheta.
- *Autoregressive models* : `ar()` in stats (with model selection).
- *ARIMA models* : `arima()` in stats is the basic function for ARIMA, SARIMA, RegARIMA, and subset ARIMA models. It is enhanced in the fable package via the `ARIMA()` function which allows for automatic modelling. Similar functionality is provided in the forecast package via the `auto.arima()` function. `arma()` in the tseries package provides different algorithms for ARMA and subset ARMA models. Other estimation methods including the innovations algorithm are provided by itsmr. arima2 provides a random-restart estimation algorithm to replace `stats::arima()`. Other estimation methods including the innovations algorithm are provided by itsmr. Package gsarima contains functionality for Generalized SARIMA time series simulation. bayesforecast fits Bayesian time series models including seasonal ARIMA and ARIMAX models. BayesARIMAX implements Bayesian estimation of ARIMAX models. Robust ARIMA modeling is provided in the robustarima package. The mar1s package handles multiplicative AR(1) with seasonal processes. TSTutorial provides an interactive tutorial for Box-Jenkins modelling. Improved prediction intervals for ARIMA and structural time series models are provided by tsPI. ARIMA models with multiple seasonal periods can be handled with tfarima and smooth.
- *Periodic ARMA models* : partsm provides for periodic autoregressive time series models, while perARMA and pcts implement periodic ARMA modelling and other procedures for periodic time series analysis.
  - *Long memory models* : Some facilities for fractional differenced ARFIMA models are provided in the fracdiff package. The arfima package has more advanced and general facilities for ARFIMA and ARIMA models, including dynamic regression (transfer function) models. Additional methods for fitting and simulating non-stationary ARFIMA models are in nsarfima. LongMemoryTS provides a collection of functions for analysing long memory time series. Fractionally differenced Gegenbaur ARMA processes are handled by garma. esemifar provides tools for nonparametric smoothing of long-memory time series.
- *Transfer function* models are provided by the `arfima` function in the arfima and the tfarima packages.
- *Structural (or unobserved component) models* are implemented in `StructTS()` in stats, while automatic modelling and forecasting are provided by UComp and autostsm. statespacer implements univariate state space models including structural and SARIMA models. Bayesian structural time series models are implemented in bsts and bayesSSM. Robust Kalman filtering is provided by RobKF. Exact observation weights for the Kalman filter and smoother are available using wex.
- *Non-Gaussian time series* can be handled with GLARMA state space models via glarma, and using Generalized Autoregressive Score models in the GAS and gasmodel packages. GlarmaVarSel provides variable selection in high-dimensional sparse GLARMA models. Dynamic Generalized Linear Models are provided by kDGLM, while Dynamic Generalized Additive Models are implemented in mvgam. Conditional Efficient Bayesian inference for nonlinear and non-Gaussian state space models is provided in bssm. PTSR includes functions to model and forecast a range of regression based dynamic models for positive time series.
- *Count time series* models are handled in the tscount and acp packages. fableCount provides a tidy interface to the INGARCH model from tscount and the GLARMA model

from glarma. coconots provides tools for convolution-closed time series models for low counts. tsintermittent implements various models for analysing and forecasting intermittent demand time series. ZIM provides for Zero-Inflated models for count time series. Zero-inflated INAR models can be handled with the ZINARp package. Semiparametric estimation and bootstrapping of INAR models is provided by the spINAR package.

- *GARCH models* : `garch()` from tseries fits basic GARCH models. Many variations on GARCH models are provided by rugarch and tsgarch. Other univariate GARCH packages include fGarch which implements ARIMA models with a wide class of GARCH innovations and robustGarch which provides robust GARCH(1,1) models. bayesforecast fits Bayesian time series models including several variations of GARCH models. There are many more GARCH packages described in the Finance task view.
- *Stochastic volatility* models are handled by stochvol in a Bayesian framework.
- *Censored time series* can be modelled using ARCensReg, which fits univariate censored regression models with autoregressive errors.
- *Diffusion models* such as Bass and Gompertz curves are provided by diffusion and DIMORA. Dynamic Gompertz models for time series growth curves are implemented in tsgc.
- *Portmanteau tests* are provided via `Box.test()` in the stats package. Additional tests are given by portes, WeightedPortTest, and testcorr .
- Outlier detection following the Chen-Liu approach is provided by tsoutliers.
- The `tsoutliers` and `tsclean` functions in the forecast package provide some simple heuristic methods for identifying and correcting outliers. tsrobprep provides methods for replacing missing values and outliers using a model-based approach. ctbi implements a procedure to clean, decompose and aggregate time series.
- Tests for possibly non-monotonic trends are provided by funtimes.
- *Time series imputation* is provided by the imputeTS package. Some more limited facilities are available using `na.interp()` from the forecast package. imputeTestbench provides tools for testing and comparing imputation methods. mtsdi implements an EM algorithm for imputing missing values in multivariate normal time series, accounting for spatial and temporal correlations. Imputation methods for multivariate locally stationary time series are in mvLSWimpute.
- The seer package implements a framework for feature-based forecast model selection.
- A standardized time series forecasting framework including many models is provided by finnts, designed for financial time series.
- Forecasts can be combined in the fable package using simple linear expressions. ForecastComb supports many forecast combination methods including simple, geometric and regression-based combinations. forecastHybrid provides functions for ensemble forecasts, combining approaches from the forecast package. opera has facilities for online predictions based on combinations of forecasts provided by the user. profoc combines probabilistic forecasts using CRPS learning.
- Point forecast evaluation is provided in the `accuracy()` function from the fable and forecast packages. Distributional forecast evaluation using scoring rules is available in fable, scoringRules and scoringutils. The Diebold-Mariano test for comparing the forecast accuracy of two models is implemented in the `dm.test()` function in forecast. ForeComp generates a size-power tradeoff plot for a given Diebold-Mariano test. A multivariate version of the Diebold-Mariano test is provided by multDM. tsutils implements the Nemenyi test for comparing forecasts. greybox provides `ro()` for general rolling origin evaluation of forecasts. tstests implements several tests for time series goodness of fit and forecast evaluation.
- Tidy tools for forecasting are provided by sweep, converting objects produced in forecast to “tidy” data frames.
- Multi-step-ahead direct forecasting with several machine learning approaches are

provided in forecastML.
- onlineforecast provides a framework for fitting adaptive forecasting models, allowing forecasts to be used as inputs to models, and models to be updated as new data arrives.
- Data leakage is a problem that can occur in forecasting competitions, and the tsdataleaks package provides tools for detecting data leakage in such settings.
- *Miscellaneous* : ltsa contains methods for linear time series analysis, timsac for time series analysis and control.

Change point detection

- *Change point detection* is provided in strucchange and strucchangeRcpp (using linear regression) and in trend (using nonparametric tests). The changepoint package provides many popular changepoint methods, and ecp does nonparametric changepoint detection for univariate and multivariate series. changepoint.np implements the nonparametric PELT algorithm, while changepoint.geo implements the high-dimensional changepoint detection method GeomCP. changepointGA performs changepoint detection using a genetic algorithm. mosum provides a moving sum procedure for detecting multiple changepoints in univariate time series. InspectChangepoint uses sparse projection to estimate changepoints in high-dimensional time series. The nonparametric moving sum procedure for detecting multiple changepoints in multivariate time series is provided by CptNonPar. Sequential Change Point Detection for High-Dimensional VAR Models is implemented in VARcpDetectOnline. Rbeast provides Bayesian change-point detection and time series decomposition. Another Bayesian change-point detection package is BayesChange, which also clusters data based on common structural changes. breakfast includes methods for fast multiple change-point detection and estimation. fastcpd provides flexible and fast change point detection for regression type data, time series (ARIMA, VAR and GARCH) and any other data with a custom cost function using Sequential Gradient Descent with PELT. binsegRcpp provides an efficient C++ implementation of the popular binary segmentation heuristic (univariate data, Gaussian/Poisson/L1/Laplace losses, computes sequence of models from 1 segment to a given max number of segments). jointseg provides `Fpsn()` which implements a “Functional pruning segment neighborhood” dynamic programming algorithm (univariate data, square loss, computes best model for a certain number of changes/segments). fpop provides `Fpop()` which implements a “Functional pruning optimal partitioning” dynamic programming algorithm (univariate data, square loss, computes best model for a certain penalty for each change), as well as `multiBinSeg()` which is an efficient implementation of the popular binary segmentation heuristic (multi-variate data, Gaussian loss, computes sequence of models from 1 segment to a given max number of segments). A tidy framework for several changepoint detection algorithms is implemented in tidychangepoint.

Frequency analysis

- *Spectral density estimation* is provided by `spectrum()` in the stats package, including the periodogram, smoothed periodogram and AR estimates. Bayesian spectral inference is provided by bspec, beyondWhittle and regspec. quantspec includes methods to compute and plot Laplace periodograms for univariate time series. The Lomb-Scargle periodogram for unevenly sampled time series is computed by lomb. peacots provides inference for periodograms using an Ornstein-Uhlenbeck state space model. spectral uses Fourier and Hilbert transforms for spectral filtering. psd produces adaptive, sine-multitaper spectral density estimates. kza provides Kolmogorov-Zurbenko Adaptive Filters including break detection, spectral analysis, wavelets and KZ Fourier Transforms. multitaper also provides some multitaper spectral analysis tools. Higher-order spectral analysis is implemented in rhosa, including bispectrum, bicoherence, cross-bispectrum

and cross-bicoherence.
- *Wavelet methods* : The wavelets package includes computing wavelet filters, wavelet transforms and multiresolution analyses. Multiresolution forecasting using wavelets is also implemented in mrf. WaveletComp provides some tools for wavelet-based analysis of univariate and bivariate time series including cross-wavelets, phase-difference and significance tests. biwavelet is a port of the WTC Matlab package for univariate and bivariate wavelet analyses. mvLSW provides tools for multivariate locally stationary wavelet processes. Local PACF estimation for locally stationary wavelet processes is provided by lpacf. Locally stationary wavelet processes can be forecast using forecastLSW. LSWPlib contains functions for simulation and spectral estimation of locally stationary wavelet packet processes. Tests of white noise using wavelets are provided by hwwntest. Wavelet scalogram tools are contained in wavScalogram. Further wavelet methods can be found in the packages waveslim and wavethresh. Complex-valued wavelet spectral procedures are provided in CNLTtsa.
- *Harmonic regression* using Fourier terms is implemented in fable and forecast packages via the `fourier` function.

Decomposition and Filtering

- *Filters and smoothing* : `filter()` in stats provides autoregressive and moving average linear filtering of multiple univariate time series. The robfilter package provides several robust time series filters. `smooth()` from the stats package computes Tukey's running median smoothers, 3RS3R, 3RSS, 3R, etc. sleekts computes the 4253H twice smoothing method. mFilter implements several filters for smoothing and extracting trend and cyclical components including Hodrick-Prescott and Butterworth filters. Several filters are provided by signal including a Butterworth filter and a Savitsky-Golay filter. hpfilter implements one- and two-sided Hodrick-Prescott filters, while jumps provides a Hodrick-Prescott filter with automatically selected jumps. Corbae-Ouliaris requency domain filtering is implemented in corbouli. smoots provides nonparametric estimation of the time trend and its derivatives.
- *Decomposition* : Seasonal decomposition is discussed below. Autoregressive-based decomposition is provided by ArDec. tsdecomp implements ARIMA-based decomposition of quarterly and monthly data.
- *Singular Spectrum Analysis* is implemented in Rssa and ASSA.
- *Empirical Mode Decomposition* (EMD) and Hilbert spectral analysis is provided by EMD. Additional tools, including ensemble EMD, are available in hht. An alternative implementation of ensemble EMD and its complete variant are available in Rlibeemd.

Seasonality

- *Seasonal decomposition* : the stats package provides classical decomposition in `decompose()`, and STL decomposition in `stl()`. Enhanced STL decomposition is available in stlplus. stR provides Seasonal-Trend decomposition based on Regression. smooth and tsutils implement extended versions of classical decomposition.
- X-13-ARIMA-SEATS binaries are provided in the x13binary package, with seasonal providing an R interface and seasonalview providing a GUI. An alternative interface is provided by x12.
- An interface to the JDemetra+ seasonal adjustment software is provided by RJDemetra. ggdemetra provides associated ggplot2 functions.
- deseats includes a locally weighted regression approach, and the Berlin method.
- Seasonal adjustment of daily time series, allowing for day-of-week, time-of-month, time-of-year and holiday effects is provided by dsa. Seasonal adjustment of weekly data is provided by boiwsa.
- StructuralDecompose decomposes a time series into trend, seasonality and residuals,

allowing for level shifts.
- *Analysis of seasonality* : the bfast package provides methods for detecting and characterizing abrupt changes within the trend and seasonal components obtained from a decomposition.
- season: Seasonal analysis of health data including regression models, time-stratified case-crossover, plotting functions and residual checks.
- seas: Seasonal analysis and graphics, especially for climatology.
- sazedR: Method to estimate the period of a seasonal time series.

Stationarity, Unit Roots, and Cointegration

- *Stationarity and unit roots* : tseries provides various stationarity and unit root tests including Augmented Dickey-Fuller, Phillips-Perron, and KPSS. Alternative implementations of the ADF and KPSS tests are in the urca package, which also includes further methods such as Elliott-Rothenberg-Stock, Schmidt-Phillips and Zivot-Andrews tests. uroot provides seasonal unit root tests. CADFtest provides implementations of both the standard ADF and a covariate-augmented ADF (CADF) test. MultipleBubbles tests for the existence of bubbles based on Phillips-Shi-Yu (2015). Simulation-based unit root tests are provided by sTSD.
- *Local stationarity* : locits provides a test of local stationarity and computes the localized autocovariance. Time series costationarity determination is provided by costat. LSTS has functions for locally stationary time series analysis. Locally stationary wavelet models for nonstationary time series are implemented in wavethresh (including estimation, plotting, and simulation functionality for time-varying spectra).
- *Cointegration* : The Engle-Granger two-step method with the Phillips-Ouliaris cointegration test is implemented in tseries and urca. The latter additionally contains functionality for the Johansen trace and lambda-max tests. tsDyn provides Johansen's test and AIC/BIC simultaneous rank-lag selection. Parameter estimation and inference in a cointegrating regression are implemented in cointReg. Fractionally cointegrated VAR models are handled by FCVAR.
- *Autoregressive distributed lag (ARDL) models* are provided by ARDL, which constructs the underlying error correction model automatically. nardl and ardl.nardl both estimate nonlinear cointegrating autoregressive distributed lag models.

Nonlinear Time Series Analysis

- *Nonlinear autoregression* : Tools for nonlinear time series analysis are provided in NTS including threshold autoregressive models, Markov-switching models, convolutional functional autoregressive models, and nonlinearity tests. Various forms of nonlinear autoregression are available in tsDyn including additive AR, SETAR and LSTAR models, threshold VAR and VECM. EXPAR provides exponential AR models, while EXPARMA provides exponential ARMA models. bentcableAR implements Bent-Cable autoregression. BAYSTAR provides Bayesian analysis of threshold autoregressive models. Mixture AR models are implemented in mixAR and uGMAR. setartree implements an SETAR tree algorithm, and a SETAR forest. tseriesTARMA provides routines for Threshold ARMA model testing fitting and forecasting. Probabilistic forecasts with XGBoost and conformal inference are provided by xpect.
- *Neural network autoregression* : Neural network forecasting based on lagged inputs are provided by tsDyn, GMDH and nnfor. NlinTS includes neural network VAR, and a nonlinear version of the Granger causality test based on feedforward neural networks. TSLSTM provides forecasts using a Long Short Term Memory (LSTM) model, while an enhanced version is implemented in TSLSTMplus. TSdeeplearning implements LSTM and GRU networks. TSANN automatically identifies an artificial neural network based on forecasting accuracy. Forecasts based on echo state networks can be obtained using

echos.
- tseriesChaos provides an R implementation of the algorithms from the *TISEAN project*. DChaos provides several algorithms for detecting chaotic signals inside univariate time series.
- Autoregression Markov switching models are provided in MSwM, while dependent mixtures of latent Markov models are given in depmixS4 for categorical and continuous time series.
- *Tests* : Various tests for nonlinearity are provided in fNonlinear. tseriesEntropy tests for nonlinear serial dependence based on entropy metrics, while tseriesTARMA provides tests for nonlinearity based on threshold ARMA models.
- Additional functions for nonlinear time series are available in nlts and nonlinearTseries.

Entropy

- RTransferEntropy measures information flow between time series with Shannon and Renyi transfer entropy.
- An entropy measure based on the Bhattacharya-Hellinger-Matusita distance is implemented in tseriesEntropy.
- Various approximate and sample entropies are computed using TSEntropies.

Dynamic Regression Models

- *Dynamic linear models* : A convenient interface for fitting dynamic regression models via OLS is available in dynlm; an enhanced approach that also works with other regression functions and more time series classes is implemented in dyn. Gaussian linear state space models can be fitted using dlm (via maximum likelihood, Kalman filtering/smoothing and Bayesian methods), or using bsts which uses MCMC. dLagM provides time series regression with distributed lags. Functions for distributed lag nonlinear modelling are provided in dlnm. fastTS implements sparsity-ranked lasso methods for time series with exogenous features and/or complex seasonality. crosslag provides linear and nonlinear cross lag analysis. Distributed lag models based on Bayesian additive regression trees are implemented in dlmtree. sym.arma will fit ARMA models with regressors where the observations follow a conditional symmetric distribution.
- *Time-varying parameter* models can be fitted using the tpr package.
- greybox provides several tools for modelling and forecasting with dynamic regression models.

Pre-trained transformer models

- nixtlar allows users to interact with Nixtla's TimeGPT via the API.

Multivariate Time Series Models

- *Vector autoregressive (VAR) models* are provided via `ar()` in the basic stats package including order selection via the AIC. These models are restricted to be stationary. MTS is an all-purpose toolkit for analysing multivariate time series including VAR, VARMA, seasonal VARMA, VAR models with exogenous variables, multivariate regression with time series errors, and much more. Possibly non-stationary VAR models are fitted in the mAr package, which also allows VAR models in principal component space. Fractionally cointegrated VAR models are handled by FCVAR. bigtime estimates large sparse VAR, VARX and VARMA models, while BigVAR estimates VAR and VARX models with structured lasso penalties and svars implements data-driven structural VARs. sstvars provides a toolkit for reduced form and structural smooth transition VARs. Shrinkage estimation methods for VARs are implemented in VARshrink. More elaborate models are provided in package vars and tsDyn. Another implementation with bootstrapped prediction intervals is given in VAR.etp. bvartools assists in the set-up of Bayesian VAR models, while BVAR and bayesianVARs provide toolkits for hierarchical Bayesian VAR models. bsvars, bsvarSIGNs, and bvarsv include efficient algorithms for estimating Bayesian Structural VAR models. BMTAR and mtarm implement Bayesian Multivariate Threshold AR models. Factor-augmented VAR (FAVAR) models are estimated by a Bayesian method with FAVAR. BGVAR implements Bayesian Global VAR models. mlVAR provides multi-level vector autoregression. gmvarkit estimates Gaussian mixture VAR models. GNAR provides methods for fitting network AR models, while graphicalVAR and tsnet both estimate graphical VAR models. gdpc implements generalized dynamic principal components. pcdpca extends dynamic principal components to periodically correlated multivariate time series. mgm estimates time-varying mixed graphical models and mixed VAR models via regularized regression. nets provides estimation of sparse VARs using long run partial correlation networks for time series data. Factor-adjusted VARs using network estimation and forecasting for high-dimensional time series is implemented in fnets.

- *Nonlinear VAR models* are provided by NVAR, while quadratic VARs are implemented in quadVAR.
- *Vector error correction models* are available via the urca, ecm, vars, tsDyn packages, including versions with structural constraints and thresholding.
- *Vector exponential smoothing* is provided by smooth.
- *Dynamic factor models* are available in the dfms package using EM or two-step estimation. Dynamic factor models with sparse loadings are implemented in sparseDFM. Bayesian dynamic factor analysis is implemented in bayesdfa and bvartools. sufficientForecasting implements a factor-based approach to forecasting with dimension reduction and a possibly nonlinear forecasting function.
- *Forecast Linear Augmented Projection* (FLAP) methods are implemented in flap.
- *Time series component analysis* : ForeCA implements forecastable component analysis by searching for the best linear transformations that make a multivariate time series as forecastable as possible. HDTSA provides procedures for several high-dimensional time series analysis tools. Frequency-domain-based dynamic PCA is implemented in freqdom. tsBSS provides blind source separation and supervised dimension reduction for time series. sdrt estimates sufficient dimension reduction subspaces for time series.
- *Multivariate state space models* An implementation is provided by the KFAS package which provides a fast multivariate Kalman filter, smoother, simulation smoother and forecasting. FKF provides a fast and flexible implementation of the Kalman filter, which can deal with missing values. FKF.SP implements fast Kalman filtering through sequential processing. kalmanfilter provides an 'Rcpp' implementation of the multivariate Kalman filter for state space models that can handle missing values and exogenous data in the observation and state equations. Another implementation is given in the dlm package which also contains tools for converting other multivariate models into state space form. MARSS fits constrained and unconstrained multivariate autoregressive state-space models using an EM algorithm. mbsts provides tools for multivariate Bayesian structural time series models. All of these packages assume the observational and state error terms are uncorrelated.
- *Partially-observed Markov processes* are a generalization of the usual linear multivariate state space models, allowing non-Gaussian and nonlinear models. These are implemented in the pomp package.
- Multivariate stochastic volatility models (using latent factors) are provided by factorstochvol. Multivariate ARCH models are implemented in tsmarch.
- High-dimensional sparse multivariate GLARMA models are handled by MultiGlarmaVarSel including variable selection.
- Multivariate Dynamic Generalized Additive Models are implemented in mvgam.

Analysis of large groups of time series

- *Time series features* are computed in feasts for time series in `tsibble` format. They are computed using tsfeatures for a list or matrix of time series in `ts` format. In both packages, many built-in feature functions are included, and users can add their own. Rcatch22 provides fast computation of 22 features identified as particularly useful. theft calculates time series features from various R and Python packages, while theftdlc is a companion package providing analysis and visualization functions. Feature extraction for ordinal time series is provided by otsfeatures.
- *Time series clustering* is implemented in TSclust, dtwclust, BNPTSclust and pdc.
- TSdist provides distance measures for time series data.
- TSrepr includes methods for representing time series using dimension reduction and feature extraction.
- Methods for plotting and forecasting collections of hierarchical and grouped time series are provided by fable and hts. thief uses hierarchical methods to reconcile forecasts of temporally aggregated time series. FoReco provides various forecast reconciliation methods for cross-sectional, temporal, and cross-temporal constrained time series. Probabilistic reconciliation of hierarchical forecasts via conditioning is available in bayesRecon. Degenerate hierarchical structures are handled by htsDegenerateR.

Dynamic time warping

- Dynamic time warping algorithms are provided by dtw for computing and plotting pairwise alignments between time series.
- Parametric time warping is implemented in ptw.
- rucrdtw provides R bindings for functions from the UCR Suite to enable ultrafast subsequence search for the best match under Dynamic Time Warping and Euclidean Distance.
- IncDTW provides incremental calculation of dynamic time warping for streaming time series.
- Time-weighted dynamic time warping is provided by twdtw.

Functional time series

- Tools for visualizing, modeling, forecasting and analysing functional time series are implemented in pkg(“ftsa”)`. NTS also implements functional autoregressive models. Seasonal functional autoregression models are provided by Rsfar. fpcb implements predictive confidence bands for functional time series.
- fdaACF estimates the autocorrelation function for functional time series.
- freqdom.fda provides implements of dynamical functional principal components for functional time series.
- STFTS contains stationarity, trend and unit root tests for functional time series.
- hdftsa offers methods for visualizing, modelling, and forecasting high-dimensional functional time series.

Matrix and tensor-valued time series

- MEFM implements main effect matrix factor models for matrix time series.
- tensorTS provides functions for estimation, simulation and prediction of factor and autoregressive models for matrix and tensor valued time series.
- Time series tensor factor models are implemented in TensorPreAve.
- RTFA provides robust factor analysis for tensor time series.

Continuous time models

- carfima allows for continuous-time ARFIMA models.
- Simulation and inference for stochastic differential equations is provided by sde and

yuima.
- Sim.DiffProc simulates and models stochastic differential equations.
- resde provides maximum likelihood estimation for univariate reducible stochastic differential equation models.

Resampling

- *Bootstrapping* : The boot package provides function `tsboot()` for time series bootstrapping, including block bootstrap with several variants. blocklength allows for selecting the optimal block-length for a dependent bootstrap. `tsbootstrap()` from tseries provides fast stationary and block bootstrapping. Maximum entropy bootstrap for time series is available in meboot. BootPR computes bias-corrected forecasting and bootstrap prediction intervals for autoregressive time series. bootUR implements bootstrap unit root tests.

Time Series Data

- Various data sets in tsibble format are provided by tsibbledata.
- gratis generates new time series with diverse and controllable characteristics using mixture autoregression models.
- Data from Cryer and Chan (2010, 2nd ed) *Time series analysis with applications in R* are in the TSA package.
- Data from Hyndman and Athanasopoulos (2018, 2nd ed) *Forecasting: principles and practice* are in the fpp2 package.
- Data from Hyndman and Athanasopoulos (2021, 3rd ed) *Forecasting: principles and practice* are in the fpp3 package.
- Data from Hyndman, Koehler, Ord and Snyder (2008) *Forecasting with exponential smoothing* are in the expsmooth package.
- Data from Makridakis, Wheelwright and Hyndman (1998, 3rd ed) *Forecasting: methods and applications* are in the fma package.
- Data from Shumway and Stoffer (2017, 4th ed) *Time Series Analysis and Its Applications: With R Examples* are in the astsa package.
- Data from Tsay (2005, 2nd ed) *Analysis of Financial Time Series* are in the FinTS package.
- Data from Woodward, Gray, and Elliott (2016, 2nd ed) *Applied Time Series Analysis with R* are in the tswge package.
- AER and Ecdat both contain many data sets (including time series data) from many econometrics text books
- Data from the M and M3 forecasting competitions are provided in the Mcomp package. Tcomp provides data from the 2010 IJF Tourism Forecasting Competition. The M4 competition data are available from M4comp2018. Data from the M5 forecasting competition can be downloaded using m5.
- *National time series data:* readabs downloads, imports and tidies time series data from the *Australian* Bureau of Statistics. bbk provides access to the *German* Deutsche Bundesbank and European Central Bank time series data. bundesbank also allows access to the time series databases of the Deutsche Bundesbank, while data from the European Central Bank can also be accessed via ecb. BETS provides access to the most important economic time series in *Brazil*. Data from the Banque de France can be downloaded using rwebstat *(archived)*. Data from *Switzerland* via dataseries.org can be downloaded and imported using dataseries. Macroeconomic time series for Africa can be obtained via africamonitor. ugatsdb provides an API to access time series data for *Uganda*, while samadb does the same for *South Africa*. Economic time series and other data from FRED (the Federal Reserve Economic Data) can be retrieved using fredr.
- *Time series databases:* rdbnomics provides access to hundreds of millions of time series from DBnomics. ifo is a client for downloading time series data from the Ifo Institute.

influxdbr provides an interface to the InfluxDB time series database. pdfetch provides facilities for downloading economic and financial time series from public sources. Data from the Quandl online portal to financial, economical and social datasets can be queried interactively using the Quandl package. tsdb implements a simple database for numerical time series.
- *Synthetic data* are produced by `simulate()` in forecast package or `generate()` in fable, given a specific model. gratis generates new time series with diverse and controllable characteristics using mixture autoregression models. synthesis generates synthetic time series from commonly used statistical models, including linear, nonlinear and chaotic systems. tssim flexibly simulates daily or monthly time series using seasonal, calendar, and outlier components.

Miscellaneous

- EBMAforecast: Ensemble Bayesian model averaging forecasts using Gibbs sampling or EM algorithms.
- ensembleBMA: Bayesian Model Averaging to create probabilistic forecasts from ensemble forecasts and weather observations.
- FeedbackTS: Analysis of fragmented time directionality to investigate feedback in time series.
- gsignal is an R implementation of the Octave package "signal", containing a variety of signal processing tools.
- paleoTS: Modeling evolution in paleontological time series.
- pastecs: Regulation, decomposition and analysis of space-time series.
- PSF: Forecasting univariate time series using pattern-sequences.
- RGENERATE provides tools to generate vector time series.
- RMAWGEN is set of S3 and S4 functions for spatial multi-site stochastic generation of daily time-series of temperature and precipitation making use of VAR models. The package can be used in climatology and statistical hydrology.
- RSEIS: Seismic time series analysis tools.
- rts: Raster time series analysis (e.g., time series of satellite images).
- SLBDD: Functions for analysing large-scale time series, based on the book "Statistical Learning with Big Dependent Data" (Pena & Tsay, 2021).
- spTimer: Spatio-temporal Bayesian modelling.
- surveillance: Temporal and spatio-temporal modeling and monitoring of epidemic phenomena.
- Tides: Functions to calculate characteristics of quasi periodic time series, e.g. observed estuarine water levels.
- TSEAL: Multivariate time series classification based on a Discrete Wavelet Transform.
- tsfknn: Time series forecasting with k-nearest-neighbours.
- tsModel: Time series modeling for air pollution and health.

CRAN packages

Core:	fable, feasts, forecast, tseries, tsibble, zoo.
Regular:	acp, AER, africamonitor, aion, almanac, anytime, ARCensReg, ArDec, ARDL, ardl.nardl, arfima, arima2, ASSA, astsa, autostsm, BayesARIMAX, BayesChange, bayesdfa, bayesforecast, bayesianVARs, bayesRecon, bayesSSM, BAYSTAR, bbk, bentcableAR, BETS, beyondWhittle, bfast, BGVAR, bigtime, BigVAR, binsegRcpp, biwavelet, blocklength, BMTAR, BNPTSclust, boiwsa, boot, BootPR, bootUR, breakfast, bspec, bssm, bsts, bsvars, bsvarSIGNs, bundesbank, BVAR, bvarsv, bvartools, CADFtest, carfima, CFtime, changepoint, changepoint.geo, changepoint.np, changepointGA, chron, clock, CNLTtsa, coconots, cointReg, collapse,

corbouli, costat, CptNonPar, crosslag, ctbi, data.table, dataseries, datetimeoffset, DChaos, dCovTS, depmixS4, deseats, dfms, diffusion, DIMORA, disaggR, dLagM, dlm, dlmtree, dlnm, dsa, DTSg, dtts, dtw, dtwclust, dygraphs, dyn, dynlm, EBMAforecast, ecb, Ecdat, echos, ecm, ecp, EMD, ensembleBMA, era, esemifar, EXPAR, EXPARMA, expsmooth, fable.prophet, fableCount, fabletools, factorstochvol, fanplot, fastcpd, fastTS, FAVAR, FCVAR, fdaACF, FeedbackTS, fGarch, finnts, FinTS, FKF, FKF.SP, flap, fma, fnets, fNonlinear, ForeCA, ForecastComb, forecastHybrid, forecastLSW, forecastML, FoReco, ForeComp, forecTheta, fpcb, fpop, fpp2, fpp3, fracdiff, fredr, freqdom, freqdom.fda, funtimes, garma, GAS, gasmodel, gdpc, ggdemetra, gglinedensity, ggseas, glarma, GlarmaVarSel, GMDH, gmvarkit, GNAR, graphicalVAR, gratis, gravitas, greybox, gsarima, gsignal, hdftsa, HDTSA, hht, hpfilter, hts, htsDegenerateR, hwwntest, ifo, imputeTestbench, imputeTS, IncDTW, influxdbr, InspectChangepoint, itsmr, jalcal, jointseg, jumps, kalmanfilter, kDGLM, KFAS, kza, legion, linevis, locits, lomb, LongMemoryTS, lpacf, LSTS, LSWPlib, ltsa, lubridate, m5, MAPA, mAr, mar1s, MARSS, mbsts, Mcomp, meboot, MEFM, mFilter, mgm, mixAR, mlVAR, modeltime, modeltime.resample, mondate, mosum, mrf, MSwM, mtarm, MTS, mtsdi, multDM, MultiGlarmaVarSel, MultipleBubbles, multitaper, mvgam, mvLSW, mvLSWimpute, nanotime, nardl, nets, nixtlar, NlinTS, nlts, nnfor, nonlinearTseries, nsarfima, NTS, NVAR, onlineforecast, opera, otsfeatures, paleoTS, partsm, parttime, pastecs, pcdpca, pcts, pdc, pdfetch, peacots, perARMA, pomp, portes, profoc, prophet, psd, PSF, PTSR, ptw, qlcal, quadVAR, Quandl, quantspec, Rbeast, Rcatch22, rdbnomics, readabs, regspec, resde, RGENERATE, rhosa, RJDemetra, Rlgt, Rlibeemd, RMAWGEN, robfilter, RobKF, robustarima, robustGarch, roll, RSEIS, Rsfar, Rssa, RTFA, RTransferEntropy, rts, rucrdtw, rugarch, runner, runstats, samadb, sazedR, scoringRules, scoringutils, sde, sdrt, seas, season, seasonal, seasonalview, seer, setartree, signal, Sim.DiffProc, SLBDD, sleekts, slider, smooth, smoots, sparseDFM, spectral, spINAR, spTimer, sstvars, statespacer, STFTS, stlplus, stochvol, stR, strucchange, strucchangeRcpp, StructuralDecompose, sTSD, sufficientForecasting, sugrrants, surveillance, svars, sweep, sym.arma, synthesis, tbrf, Tcomp, tempdisagg, TensorPreAve, tensorTS, testcorr, tfarima, tframe, theft, theftdlc, thief, Tides, tidychangepoint, timechange, timeDate, timeSeries, timeseriesdb, timetk, timsac, tis, tpr, trend, TSA, TSANN, tsbox, tsBSS, TSclust, tscount, tsdataleaks, tsdb, tsdecomp, TSdeeplearning, tsdisagg2, TSdisaggregation, TSdist, tsDyn, TSEAL, TSEntropies, tseriesChaos, tseriesEntropy, tseriesTARMA, tsfeatures, tsfknn, tsgarch, tsgc, tsibbledata, tsibbletalk, tsintermittent, tsissm, TSLSTM, TSLSTMplus, tsmarch, tsModel, tsnet, tsoutliers, tsPI, TSrepr, tsrobprep, tssim, TSstudio, tstests, TSTutorial, tsutils, tswge, twdtw, UComp, ugatsdb, uGMAR, urca, uroot, VAR.etp, VARcpDetectOnline, vars, VARshrink, VedicDateTime, WaveletComp, wavelets, waveslim, wavethresh, wavScalogram, WeightedPortTest, wex, wktmo, x12, x13binary, xpect, xts, yuima, ZIM, ZINARp, ZRA.

Archived: rwebstat.

Related links

- TISEAN Project

Other resources

- CRAN Task View: Econometrics
- CRAN Task View: Environmetrics
- CRAN Task View: Finance
- GitHub Project: M4comp2018