Package ‘mlVAR’

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Description Estimates the multi-level vector autoregression model on time-series data.
               Three network structures are obtained: temporal networks, contemporaneous
               networks and between-subjects networks.

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NeedsCompilation no

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**getNet**

*Gets a network structure*

**Description**

This function is simply a wrapper around the plotting method for mlVAR objects, that extracts the network structure rather than plotting them.

**Usage**

```r
getNet(x, ...)
```

**Arguments**

- `x` An `mlVAR` or `mlVARsim0` object.
- `...` Arguments sent to `plot.mlVAR`

**Author(s)**

Sacha Epskamp <mail@sachaepskamp.com>

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**importMplus**

*Import output from Mplus*

**Description**

This function imports the output from an Mplus model that has been generated by mlVAR. It can be used to make manual changes to the input file.

**Usage**

```r
importMplus(outfile)
```

**Arguments**

- `outfile` Location of Mplus output file.

**Author(s)**

Sacha Epskamp <mail@sachaepskamp.com>
The function `mlVAR` computes estimates of the multivariate vector autoregression model. This model returns three structures: temporal effects (e.g., lag-1 regression weights), contemporaneous relationships (correlations or partial correlations) and between-subject effects (correlations and partial correlations). See details.

```
mlVAR(data, vars, idvar, lags = 1, dayvar, beepvar,
      estimator = c("default", "lmer", "lm", "Mplus"),
      contemporaneous = c("default", "correlated",
         "orthogonal", "fixed", "unique"), temporal =
        c("default", "correlated", "orthogonal", "fixed",
           "unique"), nCores = 1, verbose = TRUE, compareToLags,
        scale = TRUE, scaleWithin = FALSE, AR = FALSE,
        MplusSave = TRUE, MplusName = "mlVAR", iterations = "(2000)",
        chains = nCores, signs, orthogonal
      )
```

**Arguments**

- **data**: Data frame
- **vars**: Vectors of variables to include in the analysis
- **idvar**: String indicating the subject ID
- **lags**: Vector indicating the lags to include
- **dayvar**: String indicating assessment day. Adding this argument makes sure that the first measurement of a day is not regressed on the last measurement of the previous day. IMPORTANT: only add this if the data has multiple observations per day.
- **beepvar**: Optional string indicating assessment beep per day. Adding this argument will cause non-consecutive beeps to be treated as missing!
- **estimator**: The estimator to be used. "lmer" for sequential univariate multi-level estimation, "Mplus" for multivariate Bayesian estimation (requires Mplus), and "lm" for fixed effects estimation.
- **contemporaneous**: How should the contemporaneous networks be estimated? These networks are always estimated post-hoc by investigating the residuals of the temporal models. "correlated" and "orthogonal" run second multi-level models in which the networks are estimated using node-wise estimation. "fixed" and "unique" simply correlate the residuals, either by computing one network for all subjects (fixed) or a single network per per subject.
temporal  How should the temporal effects be estimated? "correlated" estimates correlated random effects, "orthogonal" estimates non-correlated random effects and "fixed" estimates a model in which only the intercept is random. Defaults to "correlated" when the number of variables is less than 6 and "orthogonal" otherwise. "unique" uses lm to estimate an unique model for each subject.

nCores  Number of cores to use in computation

verbose  Logical indicating if console messages and the progress bar should be shown.

scale  Logical, should variables be standardized before estimation?

scaleWithin  Logical, should variables be scaled within-person (set to FALSE to only center within-person)

compareToLags  A vector indicating which lags to base the data on. If the model is to be compared with a model with multiple lags using mlVARcompare, this argument must be used to make sure the number of observations is the same in both models (e.g., a lag 1 model can model the second observation of a day and a lag-2 model can’t, causing different number of observations and incomparable models). It is suggested to not use this argument unless you want to compare models, and always run mlVAR without using this argument afterwards in the selected model.

AR  Logical, should an auto-regression only model be fitted?

MplusSave  Logical, should the Mplus model file and output be saved?

MplusName  Name of the Mplus model file and output (without extensions)

iterations  The string used to define the number of iterations in Mplus

chains  Number of Mplus chains

signs  Optional matrix fixing the signs of contemporaneous correlations. Is estimated by running mlVAR with estimator = "lmer" if missing.

orthogonal  Deprecated argument only added for backward competability. Ignore.

Details

This function estimates the multi-level VAR model to obtain temporal, contemporaneous and between-subject effects using nodewise estimation. Temporal and between-subject effects are obtained directly from the models and contemporaneous effects are estimated post-hoc by correlating the residuals. See arxiv.org/abs/1609.04156 for details.

Setting estimator = "Mplus" will generate a Mplus model, run the analysis and read the results into R. Mplus 8 is required for this estimation. It is recommended to set contemporaneous = "fixed", though not required. For the estimation of contemporaneous random effects, the signs of contemporaneous *correlations * (not partial correlations) need be set (or estimated) via the signs argument.

Value

An mlVAR object

Author(s)

Sacha Epskamp (mail@sachaepskamp.com)
References


See Also

mlVARcompare, summary.mlVAR, plot.mlVAR

Examples

## Not run:
### Small example ###
# Simulate data:
Model <- mlVARsim(nPerson = 50, nNode = 3, nTime = 50, lag=1)

# Estimate using correlated random effects:
fit1 <- mlVAR(Model$Data, vars = Model$vars, idvar = Model$idvar, lags = 1, temporal = "correlated")

# Print some pointers:
print(fit1)

# Summary of all parameter estimates:
summary(fit1)

# Compare temporal relationships:
layout(t(1:2))
plot(Model, "temporal", title = "True temporal relationships", layout = "circle")
plot(fit1, "temporal", title = "Estimated temporal relationships", layout = "circle")

# Compare contemporaneous partial correlations:
layout(t(1:2))
plot(Model, "contemporaneous", title = "True contemporaneous relationships", layout = "circle")
plot(fit1, "contemporaneous", title = "Estimated contemporaneous relationships", layout = "circle")

# Compare between-subjects partial correlations:
layout(t(1:2))
plot(Model, "between", title = "True between-subjects relationships", layout = "circle")
plot(fit1, "between", title = "Estimated between-subjects relationships", layout = "circle")

# Run same model with non-correlated temporal relationships and fixed-effect model:
fit2 <- mlVAR(Model$Data, vars = Model$vars, idvar = Model$idvar, lags = 1, temporal = "orthogonal")
fit3 <- mlVAR(Model$Data, vars = Model$vars, idvar = Model$idvar, lags = 1,
### Large example ###
Model <- mlVARsim(nPerson = 100, nNode = 10, nTime = 100, lag = 1)

# Correlated random effects no longer practical. Use orthogonal or fixed:
fit4 <- mlVAR(Model$Data, vars = Model$vars, idvar = Model$idvar, lags = 1, temporal = "orthogonal")
fit5 <- mlVAR(Model$Data, vars = Model$vars, idvar = Model$idvar, lags = 1, temporal = "fixed")

# Compare models:
mlVARcompare(fit4, fit5)

# Compare temporal relationships:
layout(t(1:2))
plot(Model, "temporal", title = "True temporal relationships", layout = "circle")
plot(fit4, "temporal", title = "Estimated temporal relationships", layout = "circle")

# Compare contemporaneous partial correlations:
layout(t(1:2))
plot(Model, "contemporaneous", title = "True contemporaneous relationships", layout = "circle")
plot(fit4, "contemporaneous", title = "Estimated contemporaneous relationships", layout = "circle")

# Compare between-subjects partial correlations:
layout(t(1:2))
plot(Model, "between", title = "True between-subjects relationships", layout = "circle")
plot(fit4, "between", title = "Estimated between-subjects relationships", layout = "circle")

## End(Not run)

### Description ###
These functions return a table of the fixed and random effects.

FUNCTIONS ARE DEPRECATED AND WILL BE REMOVED SOON.
Usage

fixedEffects(object, digits = 5)
randomEffects(object, digits = 5)

Arguments

object A mlVAR object
digits Number of digits to output

Author(s)

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Description

The function mlVAR0 computes estimates of the multivariate vector autoregression model as introduced by Bringmann et al. (2013) which can be extended through treatment effects, covariates and pre- and post assessment effects.

FUNCTION IS DEPRECATED AND WILL BE REMOVED SOON.

Usage

mlVAR0(data, vars, idvar, lags = 1, dayvar, beepvar,
        periodvar, treatmentvar, covariates, timevar,
        maxTimeDiff, control = list(optimizer = "bobyqa"),
        verbose = TRUE, orthogonal, estimator = c("lmer",
        "lmmlasso"), method = c("default", "stepwise",
        "movingWindow"), laginteractions = c("none", "mains",
        "interactions"), critFun = BIC, lambda = 0,
        center = c("inSubject","general","none"))

Arguments

data Data frame
vars Vectors of variables to include in the analysis
idvar String indicating the subject ID
lags Vector indicating the lags to include
dayvar String indicating assessment day (if missing, every assessment is set to one day)
beepvar String indicating assessment beep per day (if missing, is added)
periodvar String indicating the period (baseline, treatment period, etc.) of assessment (if missing, every assessment is set to one period)
treatmentvar  Character vector indicating treatment
covariates    Character indicating covariates independent of assessment.
timevar       Character indicating the time variable
maxTimeDiff   Maximum time difference to include observation pairs
control       A list of arguments sent to lmerControl
verbose       Logical to print progress to the console
orthogonal    Logical to indicate if orthogonal estimation (no correlated random effects) should
              be used. Defaults to FALSE if the number of nodes is less than 6 and TRUE otherwise
estimator     Estimator to use. Note: lmmlasso implementation is very experimental
method        Method to use. Experimental
lagInteractions Experimental, do not use.
critFun       Experimental, do not use.
lambda        lmmlasso lambda parameter
center        Centering to be used. "inSubject" uses within-person centering, "general" uses grand-mean
              centering and "none" does not use centering. IMPORTANT NOTE: "inSubject" leads to
              coefficients to resemble within-person slopes, the other centering option leads to
              coefficients to be a blend of within and between person slopes.
Details

mlVAR0 has been built to extract individual network dynamics by estimating a multilevel vector
autoregression model that models the time dynamics of selected variables both within an individual
and on group level. For example, in a lag-1-model each variable at time point t is regressed to a
lagged version of itself at time point t-1 and all other variables at time point t-1. In psychological
research, for example, this analysis can be used to relate the dynamics of symptoms on one day (as
assessed by experience sampling methods) to the dynamics of these symptoms on the consecutive
day.

Value

mlVAR0 returns a 'mlVAR0' object containing

fixedEffects  A matrix that contains all fixed effects coefficients with dependent variables as
              rows and the lagged independent variables as columns.
se.fixedEffects A matrix that contains all standard errors of the fixed effects.
randomEffects A list of matrices that contain the random effects coefficients.
randomEffectsVariance A matrix containing the estimated variances between the random-effects terms
pvals         A matrix that contains p-values for all fixed effects.
pseudologlik  The pseudo log-likelihood.
BIC           Bayesian Information Criterion, i.e. the sum of all univariate models' BICs
input         List containing the names of variables used in the analysis
Author(s)

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References


See Also

fixedEffects, fixedEffects

Examples

## Not run:
### Small network ###

nVar <- 3
nPersion <- 25
nTime <- 25

# Simulate model and data:
Model <- mlVARsim(nPerson,nVar,nTime,sparsity = 0.5)

# Run mlVAR0:
Res <- mlVAR0(Model)

# Compare true fixed model with significant edges of estimated fixed model:
layout(t(1:2))
plot(Model, "fixed", title = "True model", layout="circle", edge.labels = TRUE)
plot(Res, "fixed", title = "Estimated model", layout = "circle", onlySig = TRUE, alpha = 0.05, edge.labels = TRUE)

# Compare true and estimated individual differences in parameters:
layout(t(1:2))
plot(Model, "fixed", title = "True model", layout="circle", edge.color = "blue", edge.labels = TRUE)
plot(Res, "fixed", title = "Estimated model", layout = "circle", edge.color = "blue", edge.labels = TRUE)

# Compare networks of subject 1:
layout(t(1:2))
plot(Model, "subject", subject = 1, title = "True model", layout="circle", edge.labels = TRUE)
plot(Res, "subject", subject = 1, title = "Estimated model", layout = "circle", edge.labels = TRUE)

### Large network ###

nVar <- 10
nPerson <- 50
nTime <- 50

# Simulate model and data:
Model <- mlVARsim0(nPerson,nVar,nTime, sparsity = 0.5)

# Run orthogonal mlVAR:
Res <- mlVAR0(Model, orthogonal = TRUE)

# Compare true fixed model with significant edges of estimated fixed model:
layout(t(1:2))
plot(Model,"fixed", title = "True model",layout="circle")
plot(Res,"fixed", title = "Estimated model", layout = "circle", onlySig = TRUE,
     alpha = 0.05)

# Compare true and estimated individual differences in parameters:
layout(t(1:2))
plot(Model,"fixed", title = "True model",layout="circle", edge.color = "blue")
plot(Res,"fixed", title = "Estimated model", layout = "circle", edge.color = "blue")

# Compare networks of subject 1:
layout(t(1:2))
plot(Model,"subject",subject = 1, title = "True model",layout="circle")
plot(Res,"subject",subject = 1,title = "Estimated model", layout = "circle")

## End(Not run)

---

**mlVAR0-methods**

**print and summary functions for mlVAR0 objects**

**Description**

Create a short summary of an object created by *mlVAR0*.

FUNCTION IS DEPRECATED AND WILL BE REMOVED SOON.

**Usage**

```r
## S3 method for class 'mlVAR0'
print(x, ...)
## S3 method for class 'mlVAR0'
summary(object, ...)
```

**Arguments**

- `object` A "mlVAR0" object
- `x` A "mlVAR0" object
- `...` Not used
mlVARcompare

Description

This function compares the fit of several mlVAR models. Since an mlVAR model is a combination of univariate models this function will compare the fits for each univariate model.

Usage

mlVARcompare(...)

Arguments

... Any number of objects obtained from mlVAR

Details

Important to note is that the number of observations must be equal to make models comparable. If the lags are different and compareToLags was not used in mlVAR this function will stop with an informative error message.

Author(s)

Sacha Epskamp (mail@sachaepskamp.com)

Examples

```r
## Not run:
### Small example ###
# Simulate data:
Model <- mlVARsim(nPerson = 50, nNode = 3, nTime = 50, lag=1)

# Estimate using different methods:
fit1 <- mlVAR(Model$Data, vars = Model$vars, idvar = Model$idvar, lags = 1, temporal = "correlated")
fit2 <- mlVAR(Model$Data, vars = Model$vars, idvar = Model$idvar, lags = 1, temporal = "orthogonal")
fit3 <- mlVAR(Model$Data, vars = Model$vars, idvar = Model$idvar, lags = 1, temporal = "fixed")

# Compare models:
mlVARcompare(fit1,fit2,fit3)

## End(Not run)
```
mlVARsample

Simulator function given an mlVAR object

Description

Simulates data based on an mlVAR object, estimates the mlVAR network model based on the simulated data and compares the estimated network to the mlVAR object network.

Usage

mlVARsample(object, nTime = c(25,50,100,200), nSample = 100, pMissing = 0, nReps = 100, nCores = 1, ...)

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

Arguments

object mlVAR object, or mlVARsample object in the summary method
nTime Vector with number of time points to test.
nSample Number of individuals in the dataset. It is possible to decrease the number of individuals compared to the individuals in the mlVAR object. However, it is not possible to have more individuals than there are in the mlVAR object.
pMissing Percentage of missing data to be simulated.
nReps Number of repetitions for each condition.
nCores Number of cores to use.
... Arguments sent to mlVAR.

Details

This function simulates data based on the mlVAR object. The individual networks (random effects) are used to simulate data using the graphicalVARsim function from the graphicalVAR package (Epskamp, 2020). The individual data is combined into one dataset. This dataset is used to estimate the mlVAR network.

For every condition, the function returns four values per network comparison measure (correlation, sensitivity, specificity, bias, and precision): one for the fixed temporal effects, one for the fixed contemporaneous effects, the mean comparison value of the random temporal effects, and the mean comparison value of the random contemporaneous effects.

Author(s)

Sacha Epskamp <mail@sachaepskamp.com>
mlVARsim

Simulates an mlVAR model and data

Description

Simulates an mlVAR model and data with a random variance-covariance matrix for the random effects.

Usage

mlVARsim(nPerson = 10, nNode = 5, nTime = 100, lag = 1, thetaVar = rep(1,nNode),
DF_theta = nNode * 2, mu_SD = c(1, 1), init_beta_SD = c(0.1, 1), fixedMuSD = 1,
shrink_fixed = 0.9, shrink_deviation = 0.9)

Arguments

nPerson Number of subjects
nNode Number of variables
nTime Number of observations per person
lag The maximum lag to be used
thetaVar Contemporaneous fixed effect variances
DF_theta Degrees of freedom in simulating person-specific contemporaneous covariances (e.g., the individual differences in contemporaneous effects)
mu_SD Range of standard deviation for the means
init_beta_SD Initial range of standard deviations for the temporal effects
fixedMuSD Standard deviation used in sampling the fixed effects
shrink_fixed Shrinkage factor for shrinking the fixed effects if the VAR model is not stationary
shrink_deviation Shrinkage factor for shrinking the random effects variance if the VAR model is not stationary

Author(s)
Sacha Epskamp (mail@sachaepskamp.com)

---

mlVARsim0 Old mlVAR simulation function

Description
FUNCTION IS DEPRECATED AND WILL BE REMOVED SOON.

Usage
mlVARsim0(nPerson = 10, nNode = 5, nTime = 100, sparsity = 0, parRange = c(0.22, 0.4),
propPositive = 0.5, diagPositive = TRUE, diagIncluded = TRUE, sdRange = c(0.01, 0.2),
shrinkFactor = 0.95, residualStyle = c("full", "diag"), residualShared = TRUE,
residualSDrange = c(0.05, 0.1), verbose = TRUE)

Arguments
nPerson
nNode
nTime
sparsity
parRange
propPositive
diagPositive
diagIncluded
sdRange
shrinkFactor
The function `plot.mlVAR` plots estimated model coefficients as networks using `qgraph`. These can be three networks: temporal, contemporaneous and between-subjects effects, of which the latter two can be plotted as a correlation or a partial correlation network.

### Usage

```r
## S3 method for class 'mlVAR'
plot(x, type = c("temporal", "contemporaneous", "between"),
     lag = 1, partial = TRUE, SD = FALSE, subject, order,
     nonsig = c("default", "show", "hide", "dashed"), rule
     = c("or", "and"), alpha = 0.05, onlySig = FALSE,
     layout = "spring", verbose = TRUE, ...)

## S3 method for class 'mlVARsim'
plot(x, ...)
```

### Arguments

- **x**
  - An `mlVAR` object.

- **type**
  - What network to plot?

- **lag**
  - The lag to use when `type = "temporal"`

- **partial**
  - Logical, should partial correlation matrices be plotted instead of correlation methods? Only used if `type` is "contemporaneous" or "between". Defaults to TRUE.

- **SD**
  - Logical. Plot the standard-deviation of random effects instead of the fixed effect estimate?

- **subject**
  - Subject number. If not missing, will plot the network of a specific subject instead.

- **order**
  - An optional character vector used to set the order of nodes in the network.

- **nonsig**
  - How to handle non-significant edges? Default will hide non-significant edges when p-values are available (fixed effects, partial correlations and temporal effects).
rule

How to choose significance in node-wise estimated GGMs (contemporaneous and between-subjects). "or" selects an edge as being significant if one node predicting the other is significant, and "and" requires both predictions to be significant.

alpha

Alpha level to test for significance

onlySig

Deprecated argument only used for backward compatibility.

layout

The layout argument used by qgraph

verbose

Logical, should message be printed to the console?

... Arguments sent to qgraph

Author(s)

Sacha Epskamp (mail@sachaepskamp.com)

plot.mlVAR0

Plot Method for mlVAR0

Description

The function plot.mlVAR0 plots estimated model coefficients as a network using qgraph.

FUNCTION IS DEPRECATED AND WILL BE REMOVED SOON.

Usage

## S3 method for class 'mlVAR0'
plot(x, type = c("fixed", "SD", "subject"), lag = 1,
subject, order, onlySig = FALSE, alpha, ...)

## S3 method for class 'mlVARsim0'
plot(x, type = c("fixed", "SD", "subject"), lag = 1,
subject, order, ...)  

Arguments

x 
A mlVAR0 object obtained through the mlVAR0-function

type 
Indicates whether to plot a network of fixed effects coefficients ("fixed"), the standard deviations of the random effect terms ("SD") or an individual subject's random effects network ("subject").

lag 
Vector indicating the lags to include

subject 
If type="subject", vector indicating the ID subject number

order 
Order of nodes

onlySig 
Logical. Set to TRUE to only plot significant fixed effects.

alpha 
Significance level to test edges at if onlySig == TRUE. Defaults to Bonferonni corrected alpha level of 0.05 divided by the number of fixed effects.

... Arguments sent to qgraph
simulateVAR

Author(s)
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simulateVAR

Simulate data from VAR model

Description
Simulates a timeseries using VAR parameters

Usage
simulateVAR(pars, means = 0, lags = 1, Nt = 100, init, residuals = 0.1, burnin)

Arguments
pars A square matrix or a list of square matrices indicating the VAR parameters
means A vector of means.
lags The lags to which the 'pars' argument parameters correspond. If 'pars' is a list then this argument should be a vector indicating which lags are represented by each element of the 'pars' list.
Nt Number of time points
init Initial setup. Must be a matrix of the first lags with rows corresponding to time points and columns corresponding to variables (e.g., if only two lags are used then the matrix must have two rows indicating the first two times points.)
residuals Standard deviation of the residuals or a residual covariance matrix
burnin Initial simulations not returned. Defaults to min(round(Nt/2), 100).

Author(s)
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Summary of mlVAR results

Description

Prints tables with fit indices and parameter estimates.

Usage

```r
## S3 method for class 'mlVAR'
summary(object, show = c("fit", "temporal", "contemporaneous", "between"),
         round = 3, ...)
## S3 method for class 'mlVAR'
print(x, ...)
```

Arguments

- `object`: An mlVAR object.
- `show`: Which tables to show?
- `round`: Number of digits.
- `x`: An mlVAR object.
- `...`: Not used

Author(s)

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