Package ‘mtsdi’
January 23, 2018

Version 0.3.5
Date 2018-01-02
Author Washington Junger <wjunger@ims.uerj.br> and Antonio Ponce de Leon <ponce@ims.uerj.br>
Maintainer Washington Junger <wjunger@ims.uerj.br>
Depends R (>= 3.0.0),utils,stats,gam,splines
Title Multivariate Time Series Data Imputation
Description This is an EM algorithm based method for imputation of missing values in multivariate normal time series. The imputation algorithm accounts for both spatial and temporal correlation structures. Temporal patterns can be modeled using an ARIMA(p,d,q), optionally with seasonal components, a non-parametric cubic spline or generalized additive models with exogenous covariates. This algorithm is specially tailored for climate data with missing measurements from several monitors along a given region.
License GPL (>= 2)
NeedsCompilation no
Repository CRAN
Date/Publication 2018-01-23 21:52:30 UTC

R topics documented:
edaprep . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
elapsedtime . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
getmean . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
miss . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5
mkjnw . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5
mnimput . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6
mstats . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
plot.mtsdi . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10
predict.mtsdi . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11
print.mtsdi . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12
print.summary.mtsdi . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13
summary.mtsdi . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14

Index 16
edaprep

Dataset Preparation for Analysis

Description

Prepare the dataset for exploratory data analysis

Usage

edaprep(dataset)

Arguments

dataset dataset with missing observations

Details

It replaces missing observation with the vector mean.

Value

It returns dataset filled in with NA

Author(s)

Washington Junger <wjunger@ims.uerj.br> and Antonio Ponce de Leon <ponce@ims.uerj.br>

See Also

mnimput, getmean, edaprep

Examples

data(miss)
c <- edaprep(miss)
### Description

Compute the elapsed time between start time and end time

### Usage

```
elapsedtime(st, et)
```

### Arguments

- **st**: starting time
- **et**: ending time

### Details

It returns the time the process took to run.

### Value

String of the form **hh:mm:ss**

### Note

It is not intended to be called directly.

### Author(s)

Washington Junger <wjunger@ims.uerj.br> and Antonio Ponce de Leon <ponce@ims.uerj.br>

### See Also

- `mnimput`
Description

Estimate the row mean from a mtsdi object regarding a fixed number of imputed values.

Usage

getmean(object, weighted=TRUE, mincol=1, maxconsec=3)

Arguments

- `object` imputation object
- `weighted` If TRUE, weights returned by mnimput will be used for mean computation
- `mincol` integer for the minimum number of valid values by row
- `maxconsec` integer for the maximum number of consecutive missing values in a column

Details

It is useful just in case one wants row mean estimated. If log transformation was used, mean is adjusted accordingly.

Value

A vector of rows mean with length n, where n is the number of observations.

Author(s)

Washington Junger <wjunger@ims.uerj.br> and Antonio Ponce de Leon <ponce@ims.uerj.br>

See Also

mnimput, getmean, edaprep

Examples

data(miss)
f <- ~c31+c32+c33+c34+c35
i <- mnimput(f,miss,eps=1e-3,ts=TRUE, method="spline",sp.control=list(df=c(7,7,7,7)))
m <- getmean(i,2)
**Sample Dataset**

Description

A small sample dataset for the tutorial on data imputation

Usage

data(miss)

Format

A data frame with 24 observations on the following 5 variables.

- `c31` a numeric vector with 1 missing observation
- `c32` a numeric vector with 1 missing observation
- `c33` a numeric vector with 6 missing observations
- `c34` a numeric vector with 3 missing observations
- `c35` a numeric vector with 3 missing observations

Examples

data(miss)

**Example from Johnson & Wichern’s Book**

Description

Create a data matrix from the Johnson & Wichern’s book

Usage

mkjnw()

Details

This function creates a data matrix from the Johnson & Wichern’s book.

Value

It returns a data matrix.
Author(s)

Washington Junger <wjuner@ims.uerj.br> and Antonio Ponce de Leon <ponce@ims.uerj.br>

References


See Also

mnimput

Examples

d <- mkjnw()

---

mnimput  Multivariate Normal Imputation

Description

Perform the modified EM algorithm imputation on a normal multivariate dataset

Usage

mnimput(formula, dataset, by = NULL, log = FALSE, log.offset = 1, eps = 1e-3, maxit = 1e2, ts = TRUE, method = "spline", sp.control = list(df = NULL, weights = NULL), ar.control = list(order = NULL, period = NULL), ga.control = list(formula, weights = NULL), f.eps = 1e-6, f.maxit = 1e3, ga.eps = 1e-6, ga.maxit = 1e3, verbose = FALSE, digits = getOption("digits"))

Arguments

formula  formula indicating the missing data frame, for instance, ~X1+X2+X3+...+Xp
dataset  data with missing values to be imputed
by      factor for variance windows. Default is NULL for a single variance matrix
log     logical. If TRUE data will be transformed into log scale. Default is FALSE
log.offset  If log is TRUE, log values will be shifted by this offset. Default is 1
eps     stop criterion
maxit   maximum number of iterations
ts      logical. TRUE if is time series
method  method for univariate time series filtering. It may be smooth, gam or arima. See Details
sp.control  list for Spline smooth control. See Details
This is a modified version of the EM algorithm for imputation of missing values. It is also applicable to time series data. When it is explicited the time series attribute through the argument ts, missing values are estimated accounting for both correlation between time series and time structure of the series itself. Several filters can be used for prediction of the mean vector in the E-step.

One can select the method for the univariate time series filtering by the argument method. The default method is "spline". In this case a smooth spline is fitted to each of the time series at each iteration. Some parameters can be passed to `smooth.spline` through `sm.control`. df is a vector as long as the number of columns in `dataset` holding fixed degrees of freedom of the splines. If NULL, the degrees of freedom of each spline are chosen by cross-validation. If df has length 1, this values is recycled for all the covariates. weights must be a matrix of the same size of `dataset` holding weights for `smooth.spline`. If NULL, all the observations will have weights equal to 1.

Other possibility for time series filtering is to fitting an ARIMA model for each of the time series by setting method to "arima". The ARIMA models must be identified before using this function, nonetheless. `arima` function can be partially controlled through `ar.control`. Each column of order must hold the corresponding (p, d, q) parameters for each univariate time series if period is NULL. If period is not NULL, order must also hold the multiplicative seasonality parameters, so each column of order takes the form (p, d, q, P, D, Q). period is the multiplicative seasonality period. f. eps and f. maxit control de convergence of the ARIMA fitting algorithm. Convergence problems due non stationarity may arise when using this option.

Last but not least, a very interesting approach to modelling temporal patterns to use a full fledged regression model. It is possible to use generalised aditive (or linear) models with exogenous variates to proper filtering of time patterns. One must set method to "gam" and supply a vector of formulas in `ga.control`. One must supply one formula for each covariate. Using covariates that are part of the formula of the imputation model may yield some colinearity among the variates. See `gam` and `glm` for details. In order to use regression models for the level, set method to "gam"

Simulations have shown that the algorithm is stable and yields good results on imputation of normal data.

Value

The function returns an object of class `mtsdi` containing

call function call
dataset imputed dataset
muhat  estimated mean vector
sigmahat estimated covariance matrix
missings vector holding the number of missing values on each row
iterations number of iterations until convergence or reach maxit
convergence convergence value. See Details
converged a logical indicating if the algorithm converged
time elapsed time of the process

Author(s)
Washington Junger <wjunger@ims.uerj.br> and Antonio Ponce de Leon <ponce@ims.uerj.br>

References

See Also
mnimput, predict.mtsdi, edaprep

Examples
data(miss)
f <- ~c31+c32+c33+c34+c35
## one-window covariance
i <- mnimput(f,miss,eps=1e-3,ts=TRUE, method="spline",sp.control=list(df=c(7,7,7,7,7)))
summary(i)

## two-window covariances
b<-c(rep("year1",12),rep("year2",12))
i <- mnimput(f,miss,by=b,eps=1e-3,ts=TRUE, method="spline",sp.control=list(df=c(7,7,7,7,7)))
summary(ii)
**mstats**  
*Missing Dataset Statistics*

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carry out some statistics from the incomplete dataset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>mstats(dataset)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>dataset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>This function computes the proportion of missing observations in a given dataset by rows and columns.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A list containing</td>
</tr>
<tr>
<td>rows</td>
</tr>
<tr>
<td>columns</td>
</tr>
<tr>
<td>pattern</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington Junger <a href="mailto:wjunger@ims.uerj.br">wjunger@ims.uerj.br</a> and Antonio Ponce de Leon <a href="mailto:ponce@ims.uerj.br">ponce@ims.uerj.br</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>See Also</th>
</tr>
</thead>
<tbody>
<tr>
<td>mnimput, getmean, edaprep</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>data(miss)</td>
</tr>
<tr>
<td>mstats(miss)</td>
</tr>
</tbody>
</table>
plot.mtsdi  

Plot the Imputed Matrix

Description

This function produces a plot with imputed values and the estimated level for each of the columns in the imputed matrix.

Usage

```
## S3 method for class 'mtsdi'
plot(x, vars = "all", overlay = TRUE, level = TRUE,
     points = FALSE, leg.loc = "topright", horiz = FALSE, at.once = FALSE, ...)
```

Arguments

- `x`: an object of the class mtsdi
- `vars`: a vector with the variables to plot
- `overlay`: logical. If TRUE, observed values are plotted over the imputed ones
- `level`: logical. If TRUE, the level is plotted
- `points`: logical. If TRUE, points on the observed and imputed values are plotted
- `leg.loc`: a list with x and y coordinates for the legend or a quoted string. Default is "topright". See Details
- `horiz`: logical. If TRUE, the legend will be horizontal oriented
- `at.once`: logical. If TRUE, all the variables are plotted in separate windows at once
- `...`: further options for function `plot`

Details

The `leg.loc` option may also be specified by setting one of the following quoted strings "bottomright", "bottom", "bottomleft", "left", "topleft", "top", "topright", "right", or "center". This places the legend on the inside of the plot frame at the given location with the orientation set by `horiz`. See `legend` for further details.

Author(s)

Washington Junger <wjunger@ims.uerj.br> and Antonio Ponce de Leon <ponce@ims.uerj.br>

See Also

`mnimput`
Examples

data(miss)
f <- ~cS1+c32+c33+c34+c35
i <- minput(f,miss,eps=1e-3,ts=TRUE, method="spline", sp.control=list(df=c(7,7,7,7)))
plot(i)

predict.mtsdi

Imputed Dataset Extraction

Description

Extract imputed dataset from a mtsdi object

Usage

## S3 method for class 'mtsdi'
predict(object, ...)

Arguments

object    imputation object

... further options passed to the generic function predict

Details

If log transformation was used, dataset is back transformed accordingly.

Value

A vector of row means with length n, where n is the number of observations.

Author(s)

Washington Junger <wjunger@ims.uerj.br> and Antonio Ponce de Leon <ponce@ims.uerj.br>

References

See Also

`mnimput, getmean, edaprep`

Examples

```r
data(miss)
f <- cS1+c32+c33+c34+c35
i <- mnimput(f, miss, eps=1e-3, ts=TRUE, method="spline", sp.control=list(df=c(7,7,7,7,7)))
predict(i)
```

---

### print.mtsdi

**Print Model Output**

**Description**

Printing method for the imputation model

**Usage**

```r
## S3 method for class 'mtsdi'
print(x, digits = getOption("digits"), ...)
```

**Arguments**

- `x` an object of class `summary.mtsdi`
- `digits` an integer indicating the decimal places. If not supplied, it is taken from `options`
- `...` further options passed to `print`

**Value**

This function does not return a value.

**Author(s)**

Washington Junger <wjunger@ims.uerj.br> and Antonio Ponce de Leon <ponce@ims.uerj.br>

**See Also**

`mnimput`

**Examples**

```r
data(miss)
f <- cS1+c32+c33+c34+c35
i <- mnimput(f, miss, eps=1e-3, ts=TRUE, method="spline", sp.control=list(df=c(7,7,7,7,7)))
predict(i)
```
Description

Printing method for the summary

Usage

```r
## S3 method for class 'summary.mtsdi'
print(x, digits =getOption("digits"), print.models = TRUE, ...)
```

Arguments

- `x`: an object of class `summary.mtsdi`
- `print.models`: a logical indicating that time filtering models should also be printed
- `digits`: an integer indicating the decimal places. If not supplied, it is taken from `options`
- `...`: further options passed from `summary.mtsdi`

Value

This function does not return a value.

Author(s)

Washington Junger `<wjunger@ims.uerj.br>` and Antonio Ponce de Leon `<ponce@ims.uerj.br>`

See Also

`mnimput`

Examples

```r
data(miss)
f <- ~c31+c32+c33+c34+c35
i <- mnimput(f,miss,eps=1e-3,ts=TRUE, method="spline",sp.control=list(df=c(7,7,7,7)))
summary(i)
```
Description
Print summary information on the imputation object

Usage
```r
## S3 method for class 'mtsdi'
summary(object, ...)  
```

Arguments
- `object`: an object of class `mtsdi`
- `...`: further options passed to `print.summary.mtsdi`

Value
The function returns a list containing:
- `call`: function call
- `muhat`: estimated mean vector
- `sigmahat`: estimated covariance matrix
- `iterations`: number of iterations used
- `convergence`: relative difference of covariance determinant reached
- `time`: time used in the process
- `models`: details on the models used for time filtering
- `log`: a logical indicating that data are log transformed
- `log.offset`: offset used in the log transformation in order to avoid zeros

Author(s)
Washington Junger `<wjunger@ims.uerj.br>` and Antonio Ponce de Leon `<ponce@ims.uerj.br>`

References
See Also

mnimput.predict

Examples

data(miss)
f <- ~c31+c32+c33+c34+c35
i <- mnimput(f, miss, eps=1e-3, ts=TRUE, method="spline", sp.control=list(df=c(7,7,7,7,7)))
summary(i)
Index

*Topic NA
  edaprep, 2
  elapsedtime, 3
  getmean, 4
  mkjn, 5
  mninput, 6
  mstats, 9
  plot.mtsdi, 10
  predict.mtsdi, 11
  print.mtsdi, 12
  print.summary.mtsdi, 13
  summary.mtsdi, 14

*Topic datasets
  miss, 5

*Topic multivariate
  edaprep, 2
  elapsedtime, 3
  getmean, 4
  mkjn, 5
  mninput, 6
  mstats, 9
  plot.mtsdi, 10
  predict.mtsdi, 11
  print.mtsdi, 12
  print.summary.mtsdi, 13
  summary.mtsdi, 14

*Topic smooth
  edaprep, 2
  elapsedtime, 3
  getmean, 4
  mkjn, 5
  mninput, 6
  mstats, 9
  plot.mtsdi, 10
  predict.mtsdi, 11
  print.mtsdi, 12
  print.summary.mtsdi, 13
  summary.mtsdi, 14

*Topic ts
  edaprep, 2
  elapsedtime, 3
  getmean, 4
  mkjn, 5
  mninput, 6
  mstats, 9
  plot.mtsdi, 10
  predict.mtsdi, 11
  print.mtsdi, 12
  print.summary.mtsdi, 13
  summary.mtsdi, 14

arima, 7

edaprep, 2, 2, 4, 8, 9, 12
elapsedtime, 3

gam, 7
getmean, 2, 4, 9, 12
glm, 7
legend, 10

miss, 5
mkjn, 5
mninput, 2–4, 6, 6, 8–10, 12, 13, 15
mstats, 9

options, 7, 12, 13

plot, 10
plot.mtsdi, 10
predict, 11, 15
predict.mtsdi, 8, 11
print, 12
print.mtsdi, 12
print.summary.mtsdi, 13, 14

smooth.spline, 7
summary.mtsdi, 13, 14