Package ‘MAPA’

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Type Package
Title Multiple Aggregation Prediction Algorithm
Version 2.0.4
Description Functions and wrappers for using the Multiple Aggregation Prediction Algorithm (MAPA) for time series forecasting. MAPA models and forecasts time series at multiple temporal aggregation levels, thus strengthening and attenuating the various time series components for better holistic estimation of its structure. For details see Kourentzes et al. (2014) <doi:10.1016/j.ijforecast.2013.09.006>.
LazyData yes
License GPL (&gt;= 2)
Depends forecast (&gt;= 5.3), parallel, RColorBrewer, smooth (&gt;= 1.4.7)
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BugReports https://github.com/trnnick/mapa/issues
NeedsCompilation no
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admissions  Total Non-elective G&A Admissions (FFCEs)

**Description**


**Usage**

admissions

**Format**

Time series data

**Source**

UK Department of Health: Monthly Activity Return

**Examples**

```r
tsdisplay(admissions)
```

---

mapa  Multiple Aggregation Prediction Algorithm (Wrapper)

**Description**

Wrapper to estimate and produce MAPA in- and out-of-sample forecasts. Uses mapaest and mapafor.

**Usage**

```r
mapa(y, ppy, fh=ppy, ifh=1, minimumAL=1, maximumAL=ppy,
   comb=c("w.mean","w.median","mean","median","wght"), paral=c(0,1,2),
   display=c(0,1), outplot=c(0,1), hybrid=c(TRUE,FALSE), model="ZZZ",
   type=c("ets","es"), conf.lvl=NULL, xreg=NULL, pr.comp=0, ...)```

Arguments

- **y**: In sample observations of a time series (vector). If y == "paper" then it prints paper reference.
- **ppy**: Periods in a season of the time series at the sampled frequency. If insample is a ts object then this is taken from its frequency, unless overridden.
- **fh**: Forecast horizon. Default = ppy.
- **ifh**: Lower aggregation level to use. Default = 1.
- **minimumAL**: Lowest aggregation level to use. Default = 1.
- **maximumAL**: Highest aggregation level to use. Default = ppy, maximumAL > 1.
- **comb**: Combination operator. This can be: "mean"; "median"; "wght" - where each aggregation level is weighted inversely to aggregation; "w.mean" - level and trend components are averaged, but seasonal and xreg follow the wght combination; "w.median" - as w.mean, but with median. It is suggested that for data with high sampling frequency to use one of the "w.mean" and "w.median".
- **paral**: Use parallel processing. 0 = no; 1 = yes (requires initialised cluster); 2 = yes and initialise cluster. Default is 0.
- **display**: Display calculation progress in console. 0 = no; 1 = yes. Default is 0.
- **outplot**: Provide output plot. 0 = no; 1 = yes. Default is 1.
- **hybrid**: Provide hybrid forecasts, as in Kourentzes et al. paper. If minimumAL > 1 then the minimumAL ETS forecasts are used. Default is TRUE.
- **model**: Allow only that type of ETS at each aggregation level. This follows similar coding to the ets function. The first letter refers to the error type ("A", "M" or "Z"); the second letter refers to the trend type ("N","A","Ad","M","Md", "Z", "X" or "Y"); and the third letter refers to the season type ("N","A","M", "Z", "X" or "Y"). The letters mean: "N"=none, "A"=additive, "M"=multiplicative, "Z"=automatically selected, "X"=automatically select between none and additive and "Y"=automatically select between none and multiplicative. A "d" for trend implies damped. "X" and "Y" supported only by type=="es". If used with type=="ets" a warning will be given and they will default to "Z". By default model="ZZZ". If due to sample limitation ETS cannot be calculated at an aggregation level for the selected model, then no estimation is done for that specific level.
- **type**: What type of exponential smoothing implementation to use. "es" = use from the smooth package; "ets" = use from the forecast package. Default is "es".
- **conf.lvl**: Vector of confidence level for prediction intervals. Values must be (0,1). If conf.lvl == NULL then no intervals are calculated. For example to get the intervals for 80% and 95% use conf.lvl=c(0.8,0.95).
- **xreg**: Vector or matrix of exogenous variables to be included in the MAPA. If matrix then rows are observations and columns are variables. Must be at least as long as in-sample. Additional observations are unused. Note that including xreg will force type="es".
- **pr.comp**: MAPAx can use principal component analysis to preprocess xreg. When comp is -1 then the number of retained components is chosen automatically. When comp=0 then no pre-processing is performed and the original xreg is used. Any other value represents the number of principal components retained.
Pass additional arguments to es or ets.

Details
This function calls `mapaest` and `mapafor` internally.

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Note
The calculation of the prediction intervals is based on the empirical multiple step ahead MSE. To speed up calculations set `conf.lvl=NULL`. If very long forecast horizons are requested then once no more $t+h$ MSE can be calculated the following approximation is used: $\sqrt{\text{MSE}_{t+1}}\sqrt{h}$ for the error.

Author(s)
Nikolaos Kourentzes, <nikolaos@kourentzes.com>; Fotios Petropoulos.

References
- You can find more information about MAPA at Nikos’ blog.

See Also
`mapaest`, `mapafor`, `mapasimple`.

Examples
```r
out <- mapa(admissions)
```
mapacalc

MAPA Internal Calculation of Forecasts

Description

The following function produces a simple MAPA forecast from a given origin. This is meant to be an internal function. Use mapafor instead.

Usage

mapacalc(y, mapafit, fh = 0, comb = c("w.mean","w.median","mean","median","wght"),
          outplot = c(0,1,2), hybrid = c(TRUE,FALSE), xreg=NULL)

Arguments

y
In sample observations of a time series (vector).

mapafit
Fitted MAPA model (from mapaest).

fh
Forecast horizon. Default = ppy.

comb
Combination operator. This can be: "mean"; "median"; "wght" - where each aggregation level is weighted inversly to aggregation; "w.mean" - level and trend components are averaged, but seasonal and xreg follow the wght combination; "w.median" - as w.mean, but with median. It is suggested that for data with high sampling frequency to use one of the "w.mean" and "w.median".

outplot
Provide output plot. 0 = no; 1 = time series and forecast only; 2 = time series, forecasts and components. For the components the spectral colouring scheme is used. Dark red is aggregation level 1. Default is 1.

hybrid
Provide hybrid forecasts, as in Kourentzes et al. paper. If minimumAL > 1 then the minimumAL ETS forecasts are used. Default is TRUE.

xreg
Vector or matrix of exogenous variables to be included in the MAPA. If matrix then rows are observations and columns are variables. Must be at least as long as in-sample plus fh. Additional observations are unused.

Value

forecasts
Vector with forecasts.

components
Array with MAPA components.

Author(s)

Nikolaos Kourentzes, <nikaos@kourentzes.com>; Fotios Petropoulos.
References

- You can find more information about MAPA at Nikos’ blog.

See Also

`mapafor`, `mapa`.

Examples

```r
mapafit <- mapaest(admissions, outplot=0)
mapacalc(admissions, mapafit, outplot=2)
```

---

mapaest  

**MAPA Estimation**

**Description**

The following function estimates MAPA and saves all fitted model.

**Usage**

```r
mapaest(y, ppy, minimumAL = 1, maximumAL = ppy, paral = c(0,1,2),
        display = c(0,1), outplot = c(0,1), model = "ZZZ", type=c("ets","es"),
        xreg = NULL, pr.Ncomp = 0, ...)
```

**Arguments**

- `y`  
  In sample observations of a time series (vector).
- `ppy`  
  Periods in a season of the time series at the sampled frequency. If `insample` is a `ts` object then this is taken from its frequency, unless overridden.
- `minimumAL`  
  Lowest aggregation level to use. Default = 1, `maximumAL`>1.
- `maximumAL`  
  Highest aggregation level to use. Default = `ppy`.
- `paral`  
  Use parallel processing. 0 = no; 1 = yes (requires initialised cluster); 2 = yes and initialise cluster. Default is 0.
- `display`  
  Display calculation progress in console. 0 = no; 1 = yes. Default is 0.
- `outplot`  
  Provide output plot. 0 = no; 1 = yes. Default is 0.
model

Allow only that type of ETS at each aggregation level. This follows similar coding to the ets function. The first letter refers to the error type ("A", "M" or "Z"); the second letter refers to the trend type ("N","A","Ad","M","Md","Z", "X" or "Y"); and the third letter refers to the season type ("N","A","M","Z", "X" or "Y"). The letters mean: "N"=none, "A"=additive, "M"=multiplicative, "Z"= automatically selected, "X"= automatically select between none and additive and "Y"= automatically select between none and multiplicative. A "d" for trend implies damped. "X" and "Y" supported only by type=="es". If used with type=="ets" a warning will be given and they will default to "Z". By default model="ZZZ". If due to sample limitation ETS cannot be calculated at an aggregation level for the selected model, then no estimation is done for that specific level. For aggregation levels that seasonality becomes 1 then a non-seasonal model is estimated.

type

What type of exponential smoothing implementation to use. "es" = use from the smooth package; "ets" = use from the forecast package. Default is "es"

xreg

Vector or matrix of exogenous variables to be included in the MAPA. If matrix then rows are observations and columns are variables. Must be at least as long as in-sample. Additional observations are unused. Note that including xreg will force type="es".

pr.comp

MAPAx can use principal component analysis to preprocess xreg. When comp is -1 then the number of retained components is chosen automatically. When comp=0 then no pre-processing is performed and the original xreg is used. Any other value represents the number of principal components retained.

... Pass additional arguments to es or ets.

Value

mapafit Estimated MAPA model structure.

Author(s)

Nikolaos Kourentzes, <nikolaos@kourentzes.com>; Fotios Petropoulos.

References


• You can find more information about MAPA at Nikos’ blog.

See Also

mapa, mapafor.
Examples

```r
mapafit <- mapaest(admissions)
```

Description

The following function produces in- and out-of-sample MAPA forecasts, for multiple steps ahead. This is the recommended function to use in forecasting with MAPA.

Usage

```r
mapafor(y, mapafit, fh = -1, ifh = 1,
        comb = c("w.mean","w.median","mean","median","wght"),
        outplot = c(0,1), hybrid = c(TRUE, FALSE),
        conf.lvl = NULL, xreg=NULL)
```

Arguments

- **y**: In sample observations of a time series (vector).
- **mapafit**: Fitted MAPA model (from `mapaest`).
- **fh**: Forecast horizon. Default = ppy.
- **ifh**: In-sample forecast horizon. Default = 0.
- **comb**: Combination operator. This can be: "mean"; "median"; "wght" - where each aggregation level is weighted inversely to aggregation; "w.mean" - level and trend components are averaged, but seasonal and xreg follow the wght combination; "w.median" - as w.mean, but with median. It is suggested that for data with high sampling frequency to use one of the "w.mean" and "w.median".
- **outplot**: Provide output plot. 0 = no; 1 = yes. Default is 1.
- **hybrid**: Provide hybrid forecasts, as in Kourentzes et al. paper. If minimumAL > 1 then the minimumAL ETS forecasts are used. Default is TRUE.
- **conf.lvl**: Vector of confidence level for prediction intervals. Values must be (0,1). If conf.lvl == NULL then no intervals are calculated. For example to get the intervals for 80% and 95% use conf.lvl=c(0.8,0.95).
- **xreg**: Vector or matrix of exogenous variables to be included in the MAPA. If matrix then rows are observations and columns are variables. Must be at least as long as in-sample plus fh. Additional observations are unused.

Value

- **infor**: In-sample forecasts.
- **outfor**: Out-of-sample forecasts.
- **PI**: Prediction intervals for given confidence levels.
- **MSE**: In-sample MSE error.
- **MAE**: In-sample MAE error.
mapasimple

Note

The calculation of the prediction intervals is based on the empirical multiple step ahead MSE. To speed up calculations set conf.lvl=NULL. If very long forecast horizons are requested then once no more t+h MSE can be calculated the following approximation is used: \( \sqrt{\text{MSE}_{t+1}} \times \sqrt{h} \) for the error.

Author(s)

Nikolaos Kourentzes, <nikolaos@kourentzes.com>; Fotios Petropoulos.

References

- You can find more information about MAPA at Nikos’ blog.

See Also

mapa, mapaest, mapacalc.

Examples

```r
mapafit <- mapaest(admissions, outplot=0)
out <- mapafor(admissions, mapafit)
```

Description

The following function estimates MAPA and produces out-of-sample forecasts. It is not suggested, unless only simple single origin forecasts are required.

Usage

```r
mapasimple(y, ppy=NULL, fh=ppy, minimumAL=1, maximumAL=ppy,
comb=c("w.mean", "w.median", "mean", "median", "wght"),
paral=c(0,1,2), display=c(0,1),
outplot=c(0,1), hybrid=c(TRUE, FALSE), model="ZZZ",
type=c("ets", "es"), xreg=NULL, pr.comp=0, ...)
```
Arguments

y  In sample observations of a time series (vector). If y == "paper" then it prints paper reference.

ppy  Periods in a season of the time series at the sampled frequency. If insample is a ts object then this is taken from its frequency, unless overridden.

fh  Forecast horizon. Default = ppy.

minimumAL  Lowest aggregation level to use. Default = 1, maximumAL>1.

maximumAL  Highest aggregation level to use. Default = ppy.

comb  Combination operator. This can be: "mean"; "median"; "wght" - where each aggregation level is weighted inversely to aggregation; "w.mean" - level and trend components are averaged, but seasonal and xreg follow the wght combination; "w.median" - as w.mean, but with median. It is suggested that for data with high sampling frequency to use one of the "w.mean" and "w.median".

paral  Use parallel processing. 0 = no; 1 = yes (requires initialised cluster); 2 = yes and initialise cluster. Default is 0.

display  Display calculation progress in console. 0 = no; 1 = yes. Default is 0.

outplot  Provide output plot. 0 = no; 1 = time series and forecast only; 2 = time series, forecasts and components. For the components the spectral colouring scheme is used. Dark red is aggregation level 1. Default is 1.

hybrid  Provide hybrid forecasts, as in Kourentzes et al. paper. If minimumAL > 1 then the minimumAL ETS forecasts are used. Default is TRUE.

model  Allow only that type of ETS at each aggregation level. This follows similar coding to the ets function. The first letter refers to the error type ("A", "M" or "Z"); the second letter refers to the trend type ("N","A","Ad","M","Md","Z","X" or "Y"); and the third letter refers to the season type ("N","A","M", "Z", "X" or "Y"). The letters mean: "N"=none, "A"=additive, "M"=multiplicative, "Z"=automatically selected, "X"=automatically select between none and additive and "Y"=automatically select between none and multiplicative. A "d" for trend implies damped. "X" and "Y" supported only by type=="es". If used with type=="ets" a warning will be given and they will default to "Z". By default model="ZZZ". If due to sample limitation ETS cannot be calculated at an aggregation level for the selected model, then no estimation is done for that specific level. For aggregation levels that seasonality becomes 1 then a non-seasonal model is estimated.

type  What type of exponential smoothing implementation to use. "es" = use from the smooth package; "ets" = use from the forecast package. Default is "es"

xreg  Vector or matrix of exogenous variables to be included in the MAPA. If matrix then rows are observations and columns are variables. Must be at least as long as in-sample. Additional observations are unused. Note that including xreg will force type="es".

pr.comp  MAPAx can use principal component analysis to preprocess xreg. When comp is -1 then the number of retained components is chosen automatically. When comp=0 then no pre-processing is performed and the original xreg is used. Any other value represents the number of principal components retained.

...  Pass additional arguments to es or ets.
This function calls `mapaest` and `mapacalc` internally.

**Value**

- **forecasts** Vector with forecasts.
- **components** Array with MAPA components, if output="all".

**Author(s)**

Nikolaos Kourentzes, <nikolaos@kourentzes.com>; Fotios Petropoulos.

**References**

- You can find more information about MAPA at Nikos’ blog.

**See Also**

- `mapa`.

**Examples**

```
mapasimple(admissions)
```

---

**plot.mapa.fit**

**Produce estimated MAPA fit plot**

**Description**

The following function plots the fitted components at each aggregation level of an estimated MAPA. The plot is the same as the one that can be produced optionally by mapaest.

**Usage**

```r
## S3 method for class 'mapa.fit'
plot(x, xreg.plot=c(TRUE, FALSE), ...)
```

**Arguments**

- **x** Fitted MAPA model (from mapaest).
- **xreg.plot** Add information about xreg in the figure.
- **...** Additional arguments.
Author(s)

Nikolaos Kourentzes, <nikolaos@kourentzes.com>.

References

- You can find more information about MAPA at Nikos’ blog.

See Also

`mapaest, mapa`.

Examples

```r
mapafit <- mapaest(admissions, outplot=0)
plot(mapafit)
```

---

**plotmapa**

*Produce estimated MAPA fit plot (OBSOLETE!)*

Description

The following function plots the fitted components at each aggregation level of an estimated MAPA. The plot is the same as the one that can be produced optionally by mapaest.

Usage

```r
plotmapa(mapafit)
```

Arguments

- `mapafit` Fitted MAPA model (from mapaest).

Note

The function `plotmapa` is deprecated. Use plot() instead.

Author(s)

Nikolaos Kourentzes, <nikolaos@kourentzes.com>; Fotios Petropoulos.
References

- You can find more information about MAPA at Nikos’ blog.

See Also

`mapaest`, `mapa`.

Examples

```r
mapafit <- mapaest(admissions, outplot=FALSE)
plotmapa(mapafit)
```

---

taggr

**Non-overlapping temporal aggregation**

**Description**

Non-overlapping temporal aggregation.

**Usage**

```r
taggr(y, fout, fmean=c(FALSE, TRUE), outplot=c(FALSE, TRUE))
```

**Arguments**

- `y` Time series vector (can be ts object).
- `fout` Vector containing desirable aggregation levels. Must be positive and integer. If larger than length(y) then it is ignored.
- `fmean` If TRUE the aggregated is done using mean, otherwise sum is used.
- `outplot` If TRUE a plot of the original series and the aggregated ones is produced.

**Value**

- `out` List of temporally aggregated series. If y was a ts object, then ‘out’ has ts objects with appropriate frequencies. Any non-integer frequency is set equal to 1. Series are named ALx, where x is the aggregation level.
- `all` An array containing all aggregated series in the original frequency. Series are named ALx, where x is the aggregation level.
- `idx` List of indices used to produce ‘out’ from ‘all’: y.out[[i]] <- y.all[y.idx[[i]],i]. Series are named ALx, where x is the aggregation level.
Author(s)

Nikolaos Kourentzes, <nikiolaos@kourentzes.com>.

Examples

out <- tsaggr(admissions, fout=2:12, fmean=TRUE, outplot=TRUE)
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