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 (>= 2)

Depends forecast (>= 5.3), parallel, RColorBrewer, smooth (>= 1.4.7)

URL http://kourentzes.com/forecasting/2014/04/19/multiple-aggregation-prediction-algorithm-mapa/

BugReports https://github.com/trnnick/mapa/issues

NeedsCompilation no

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R topics documented:

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admissions   *Total Non-elective G&A Admissions (FFCEs)*

Description

UK NHS Total Non-elective G&A Admissions (FFCEs). April 2008 – June 2013.

Usage

```
admissions
```

Format

Time series data

Source

UK Department of Health: Monthly Activity Return

Examples

```
tsdisplay(admissions)
```

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mapa   *Multiple Aggregation Prediction Algorithm (Wrapper)*

Description

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

Usage

```
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 overriden.
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 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".
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.

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.

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(MSE_t+1)*sqrt(h) for the error.

Author(s)

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

References

- Kourentzes N., Petropoulos F., Trapero J.R. (2014) Improving forecasting by estimating time series structural components across multiple frequencies. *International Journal of Forecasting*, **30**(**2**), 291–302.

- Kourentzes N., Petropoulos F. (2015) Forecasting with multivariate temporal aggregation: The case of promotional modelling. *International Journal of Production Economics*.

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

See Also

mapaest, mapafor, mapasimple.

Examples

```
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, <nikolaos@kourentzes.com>; Fotios Petropoulos.

References

- Kourentzes N., Petropoulos F., Trapero J.R. (2014) Improving forecasting by estimating time series structural components across multiple frequencies. *International Journal of Forecasting*, **30**(**2**), 291–302.
- Kourentzes N., Petropoulos F. (2015) Forecasting with multivariate temporal aggregation: The case of promotional modelling. *International Journal of Production Economics*.
- You can find more information about MAPA at Nikos' blog.

See Also

mapafor, mapa.

Examples

```
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

```
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.comp = 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 overriden.
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

- Kourentzes N., Petropoulos F., Trapero J.R. (2014) Improving forecasting by estimating time series structural components across multiple frequencies. *International Journal of Forecasting*, **30**(**2**), 291–302.

- Kourentzes N., Petropoulos F. (2015) Forecasting with multivariate temporal aggregation: The case of promotional modelling. *International Journal of Production Economics*.

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

See Also

mapa, mapafor.

Examples

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

---

mapafor	*MAPA Forecast*

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

```
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 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 = 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.

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(MSE_t+1)*sqrt(h) for the error.

Author(s)

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

References

- Kourentzes N., Petropoulos F., Trapero J.R. (2014) Improving forecasting by estimating time series structural components across multiple frequencies. *International Journal of Forecasting*, **30**(**2**), 291–302.
- Kourentzes N., Petropoulos F. (2015) Forecasting with multivariate temporal aggregation: The case of promotional modelling. *International Journal of Production Economics*.
- You can find more information about MAPA at Nikos' blog.

See Also

mapa, mapaest, mapacalc.

Examples

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

---

mapasimple   *MAPA Single Origin Forecast (Wrapper)*

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

```
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 overriden.
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 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".
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.

Details

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

- Kourentzes N., Petropoulos F., Trapero J.R. (2014) Improving forecasting by estimating time series structural components across multiple frequencies. *International Journal of Forecasting*, **30**(**2**), 291–302.
- Kourentzes N., Petropoulos F. (2015) Forecasting with multivariate temporal aggregation: The case of promotional modelling. *International Journal of Production Economics*.
- 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

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

Arguments

x	Fitted MAPA model (from mapaest).
xreg.plot	Add infromation about xreg in the figure.
...	Additional arguments.

Author(s)

Nikolaos Kourentzes, `<nikolaos@kourentzes.com>`.

References

- Kourentzes N., Petropoulos F., Trapero J.R. (2014) Improving forecasting by estimating time series structural components across multiple frequencies. *International Journal of Forecasting*, **30**(**2**), 291–302.
- Kourentzes N., Petropoulos F. (2015) Forecasting with multivariate temporal aggregation: The case of promotional modelling. *International Journal of Production Economics*.
- You can find more information about MAPA at Nikos' blog.

See Also

mapaest, mapa.

Examples

```
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

```
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

- Kourentzes N., Petropoulos F., Trapero J.R. (2014) Improving forecasting by estimating time series structural components across multiple frequencies. *International Journal of Forecasting*, **30**(**2**), 291–302.
- Kourentzes N., Petropoulos F. (2015) Forecasting with multivariate temporal aggregation: The case of promotional modelling. *International Journal of Production Economics*.
- You can find more information about MAPA at Nikos' blog.

See Also

mapaest, mapa.

Examples

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

---

tsaggr   *Non-overlapping temporal aggregation*

Description

Non-overlapping temporal aggregation.

Usage

```
tsaggr(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, <nikolaos@kourentzes.com>.

Examples

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

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