NAG Toolbox for MATLAB

g13bb

1 Purpose

g13bb filters a time series by a transfer function model.

2 Syntax

```
[b, ifail] = g13bb(y, mr, par, cy, nb, 'ny', ny, 'nmr', nmr, 'npar', npar)
```

3 Description

From a given series $y_1, y_2, \ldots, y_n$ a new series $b_1, b_2, \ldots, b_n$ is calculated using a supplied (filtering) transfer function model according to the equation

$$b_t = \delta_1 b_{t-1} + \delta_2 b_{t-2} + \cdots + \delta_p b_{t-p} + \omega_0 y_{t-b} - \omega_1 y_{t-b-1} - \cdots - \omega_q y_{t-b-q}. \tag{1}$$

As in the use of g13ba, large transient errors may arise in the early values of b_t due to ignorance of y_t for $t < 0$, and two possibilities are allowed.

(i) The equation (1) is applied from $t = 1 + b + q, \ldots, n$ so all terms in y_t on the right-hand side of (1) are known, the unknown set of values b_t for $t = b + q, \ldots, b + q + 1 - p$ being taken as zero.

(ii) The unknown values of y_t for $t \leq 0$ are estimated by backforecasting exactly as for g13ba.

4 References

Box G E P and Jenkins G M 1976 *Time Series Analysis: Forecasting and Control* (Revised Edition) Holden–Day

5 Parameters

5.1 Compulsory Input Parameters

1: **y(ny) – double array**

The Q'_y backforecasts starting with backforecast at time $1 - Q'_y$ to backforecast at time 0 followed by the time series starting at time 1, where $Q'_y = \mathbf{mr}(6) + \mathbf{mr}(9) \times \mathbf{mr}(10)$. If there are no backforecasts either because the ARIMA model for the time series is not known or because it is known but has no moving average terms, then the time series starts at the beginning of **y**.

2: **mr(nmr) – int32 array**

The orders vector for the filtering TF model followed by the orders vector for the ARIMA model for the time series if the latter is known. The TF model orders appear in the standard form (b, q, p) as given in the G13 Chapter Introduction. Note that if the ARIMA model for the time series is supplied then the function will assume that the first Q'_y values of the array **y** are backforecasts.

Constraints:

$\mathbf{mr}(3) \geq 0$;
$\mathbf{mr}(k) \geq 0$, for $k = 4, 5, \ldots, 10$;
if $\mathbf{mr}(10) = 0$, $\mathbf{mr}(7) + \mathbf{mr}(8) + \mathbf{mr}(9) = 0$;
if $\mathbf{mr}(10) \neq 0$, $\mathbf{mr}(7) + \mathbf{mr}(8) + \mathbf{mr}(9) \neq 0$;
$\mathbf{mr}(10) \neq 1$.

3: **par(npar) – double array**

The parameters of the filtering TF model followed by the parameters of the ARIMA model for the time series. In the TF model the parameters are in the standard order of MA-like followed by AR-like operator parameters. In the ARIMA model the parameters are in the standard order of non-seasonal AR and MA followed by seasonal AR and MA.

4: **cy – double scalar**

If the ARIMA model is known (i.e., **nmr** $= 10$), **cy** must specify the constant term of the ARIMA model for the time series. If this model is not known (i.e., **nmr** $= 3$) then **cy** is not used.

5: **nb – int32 scalar**

In addition to holding the returned filtered series, **b** is also used as an intermediate work array if the ARIMA model for the time series is known.

Constraints:

if **nmr** $= 3$, **nb** $\geq$ **ny**;
if **nmr** $= 10$, **nb** $\geq$ **ny** $+ \max(\mathbf{mr}(1) + \mathbf{mr}(2), \mathbf{mr}(3))$.

5.2 Optional Input Parameters

1: **ny – int32 scalar**

Default: The dimension of the array **y**.

the total number of backforecasts and time series data points in array **y**.

Constraint: **ny** $\geq \max\left(1 + Q'_y, \mathbf{npar}\right)$.

2: **nmr – int32 scalar**

Default: The dimension of the array **mr**.

the number of values supplied in the array **mr**. It takes the value 3 if no ARIMA model for the time series is supplied but otherwise it takes the value 10. Thus **nmr** acts as an indicator as to whether backforecasting can be carried out.

Constraint: **nmr** $= 3$ or 10.

3: **npar – int32 scalar**

Default: The dimension of the array **par**.

the total number of parameters held in array **par**.

Constraints:

if **nmr** $= 3$, **npar** $= \mathbf{mr}(2) + \mathbf{mr}(3) + 1$;
if **nmr** $= 10$, **npar** $= \mathbf{mr}(2) + \mathbf{mr}(3) + 1 + \mathbf{mr}(4) + \mathbf{mr}(6) + \mathbf{mr}(7) + \mathbf{mr}(9)$.

5.3 Input Parameters Omitted from the MATLAB Interface

wa, iwa

5.4 Output Parameters

1: **b(nb) – double array**

The filtered output series. If the ARIMA model for the time series was known, and hence Q'_y backforecasts were supplied in **y**, then **b** contains Q'_y 'filtered' backforecasts followed by the filtered series. Otherwise, the filtered series begins at the start of **b** just as the original series began at the

start of **y**. In either case, if the value of the series at time t is held in $\mathbf{y}(t)$, then the filtered value at time t is held in $\mathbf{b}(t)$.

2: **ifail – int32 scalar**

0 unless the function detects an error (see Section 6).

6 Error Indicators and Warnings

Errors or warnings detected by the function:

ifail $= 1$

On entry, **nmr** $\neq 3$ and **nmr** $\neq 10$,
or **mr**$(i) < 0$, $i = 1, 2, \ldots,$ **nmr**,
or **nmr** $= 10$ and **mr**$(10) = 1$,
or **nmr** $= 10$ and **mr**$(10) = 0$ and **mr**$(7) +$ **mr**$(8) +$ **mr**$(9) \neq 0$,
or **nmr** $= 10$ and **mr**$(10) \neq 0$, and **mr**$(7) +$ **mr**$(8) +$ **mr**$(9) = 0$,
or **npar** is inconsistent with the contents of **mr**,
or **wa** is too small,
or **b** is too small.

ifail $= 2$

A supplied model has parameter values which have failed the validity test.

ifail $= 3$

The supplied time series is too short to carry out the requested filtering successfully.

ifail $= 4$

This only occurs when an ARIMA model for the time series has been supplied. The matrix which is used to solve for the starting values for MA filtering is singular.

ifail $= -999$

Internal memory allocation failed.

7 Accuracy

Accuracy and stability are high except when the AR-like parameters are close to the invertibility boundary. All calculations are performed in ***basic precision*** except for one inner product type calculation which on machines of low precision is performed in ***additional precision***.

8 Further Comments

If an ARIMA model is supplied, a local workspace array of fixed length is allocated internally by g13bb. The total size of this array amounts to K integer elements, where K is the expression defined in the description of the parameter **wa**.

The time taken by g13bb is roughly proportional to the product of the length of the series and number of parameters in the filtering model with appreciable increase if an ARIMA model is supplied for the time series.

9 Example

```
y = [5159.0292275785;
     5165.856375167262;
```

```
    4947.452842185773;
    4729.825270337461;
    4424.452756333954;
    4072.462838586225;
    3995.520293450913;
    4142.712242307538;
    4219.739771621216;
    4452.071008250417;
    4758.013111420425;
    4834.637979606607;
    5312;
    5402;
    4960;
    4717;
    4383;
    3828;
    3665;
    3718;
    3744;
    3994;
    4150;
    4064;
    4324;
    4256;
    3986;
    3670;
    3292;
    2952;
    2765;
    2813;
    2850;
    3085;
    3256;
    3213;
    3514;
    3386;
    3205;
    3124;
    2804;
    2536;
    2445;
    2649;
    2761;
    3183;
    3456;
    3529;
    4067;
    4079;
    4082;
    4029;
    3887;
    3684;
    3707;
    3923;
    4068;
    4557;
    4975;
    5197;
    6054;
    6471;
    6277;
    5529;
    5059;
    4539;
    4236;
    4305;
    4299;
    4478;
    4561;
    4470;
```

```
     4712;
     4512;
     4129;
     3942;
     3572;
     3149;
     3026;
     3141;
     3145;
     3322;
     3384;
     3373;
     3630;
     3555;
     3413;
     3127;
     2966;
     2685;
     2642;
     2789;
     2867;
     3032;
     3125;
     3176;
     3359;
     3265;
     3053;
     2915;
     2690;
     2518;
     2523;
     2737;
     3074;
     3671;
     4355;
     4648;
     5232;
     5349;
     5228;
     5172;
     4932;
     4637;
     4642;
     4930;
     5033;
     5223;
     5482;
     5560;
     5960;
     5929;
     5697;
     5583;
     5316;
     5039;
     4972;
     5169;
     5138;
     5316;
     5409;
     5375;
     5803;
     5736;
     5643;
     5416;
     5059;
     4810;
     4937;
     5166;
     5187;
     5348;
```

```
     5483;
     5626;
     6077;
     6033;
     5996;
     5860;
     5499;
     5210;
     5421;
     5609;
     5586;
     3663;
     5829;
     6005;
     6693;
     6792;
     6966;
     7227;
     7089;
     6823;
     7286;
     7621;
     7758;
     8000;
     8393;
     8592;
     9186;
     9175];
mr = [int32(0);
     int32(13);
     int32(12);
     int32(1);
     int32(1);
     int32(0);
     int32(0);
     int32(1);
     int32(1);
     int32(12)];
par = [1.0131;
     0.0806;
     -0.015;
     -0.015;
     -0.015;
     -0.015;
     -0.015;
     -0.015;
     -0.015;
     -0.015;
     -0.015;
     -0.015;
     -0.015;
     0.9981;
     -0.0956;
     0;
     0;
     0;
     0;
     0;
     0;
     0;
     0;
     0;
     0;
     0;
     0.82;
     0.62;
     0.82];
cy = 0;
nb = int32(183);
[b, ifail] = g13bb(y, mr, par, cy, nb)
```