NAG Toolbox for MATLAB

g13dl

1 Purpose

g13dl differences and/or transforms a multivariate time series. It is intended to be used prior to g13dc to fit a vector autoregressive moving average (VARMA) model to the differenced/transformed series.

2 Syntax

```
[w, nd, ifail] = g13dl(z, tr, id, delta, 'k', k, 'n', n)
```

3 Description

For certain time series it may first be necessary to difference the original data to obtain a stationary series before calculating autocorrelations, etc. This function also allows you to apply either a square root or a log transformation to the original time series to stabilize the variance if required.

If the order of differencing required for the ith series is d_i, then the differencing operator is defined by $\delta_i(B) = 1 - \delta_{i1}B - \delta_{i2}B^2 - \cdots - \delta_{id_i}B^{d_i}$, where B is the backward shift operator; that is, $BZ_t = Z_{t-1}$. Let d denote the maximum of the orders of differencing, d_i, over the k series. The function computes values of the differenced/transformed series $W_t = (w_{1t}, w_{2t}, \ldots, w_{kt})^{\mathrm{T}}$ for $t = d+1, d+2, \ldots, n$ as follows:

$$w_{it} = \delta_i(B)z^*_{it}, \qquad i = 1, 2, \ldots, k$$

where z^*_{it} are the transformed values of the original k-dimensional time series $Z_t = (z_{1t}, z_{2t}, \ldots, z_{kt})^{\mathrm{T}}$.

The differencing parameters δ_{ij}, for $i = 1, 2, \ldots, k$; $j = 1, 2, \ldots, d_i$ must be supplied by you. If the ith series does not require differencing, then $d_i = 0$.

4 References

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

Wei W W S 1990 *Time Series Analysis: Univariate and Multivariate Methods* Addison–Wesley

5 Parameters

5.1 Compulsory Input Parameters

1: **z(kmax,n) – double array**

$\mathbf{z}(i,t)$ must contain, z_{it}, the ith component of Z_t, for $i = 1, 2, \ldots, k$ and $t = 1, 2, \ldots, n$.

Constraints:

if $\mathbf{tr}(i) =$ 'L', $\mathbf{z}(i,t) > 0.0$;
if $\mathbf{tr}(i) =$ 'S', $\mathbf{z}(i,t) \geq 0.0$, for $i = 1, 2, \ldots, k$ and $t = 1, 2, \ldots, n$.

2: **tr(k) – string array**

$\mathbf{tr}(i)$ indicates whether the ith time series is to be transformed, for $i = 1, 2, \ldots, k$.

tr$(i) =$ 'N'

No transformation is used.

tr$(i) =$ 'L'

A log transformation is used.

tr$(i) =$ 'S'

A square root transformation is used.

Constraint: **tr**$(i) =$ 'N', 'L' or 'S', for $i = 1, 2, \ldots, k$.

3: **id**(**k**) – **int32 array**

The order of differencing for each series, $d_1, d_2, \ldots, d_k$ with $d = \max(\mathbf{id}(i))$, for $i = 1, 2, \ldots, k$.

Constraint: $0 \leq \mathbf{id}(i) < \mathbf{n}$, for $i = 1, 2, \ldots, \mathbf{k}$.

4: **delta**(**kmax**,$*$) – **double array**

The first dimension of the array **delta** must be at least **k**

The second dimension of the array must be at least $\max(1, d)$, where $d = \max(\mathbf{id}(i))$

If $\mathbf{id}(i) > 0$, then $\mathbf{delta}(i,j)$ must be set equal to δ_{ij}, for $j = 1, 2, \ldots, d_i$; $i = 1, 2, \ldots, k$. If $d = 0$, then **delta** is not referenced.

5.2 Optional Input Parameters

1: **k** – **int32 scalar**

Default: The dimension of the arrays **tr**, **id**. (An error is raised if these dimensions are not equal.)

k, the dimension of the multivariate time series.

Constraint: $\mathbf{k} \geq 1$.

2: **n** – **int32 scalar**

Default: The second dimension of the array **z**.

n, the number of observations in the series, prior to differencing.

Constraint: $\mathbf{n} \geq 1$.

5.3 Input Parameters Omitted from the MATLAB Interface

kmax, work

5.4 Output Parameters

1: **w**(**kmax**,$*$) – **double array**

The first dimension of the array **w** must be at least **k**

The second dimension of the array must be at least $\mathbf{n} - d$

$\mathbf{w}(i, t)$ contains the value of $w_{i,t+d}$, for $i = 1, 2, \ldots, k$; $t = 1, 2, \ldots, n - d$.

2: **nd** – **int32 scalar**

The number of differenced values, $n - d$, in the series.

3: **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, $\mathbf{k} < 1$,
or $\mathbf{n} < 1$,
or $\mathbf{kmax} < \mathbf{k}$.

ifail $= 2$

On entry, $\mathbf{id}(i) < 0$, for some $i = 1, 2, \ldots, k$,
or $\mathbf{id}(i) \geq \mathbf{n}$, for some $i = 1, 2, \ldots, k$.

ifail $= 3$

On entry, at least one of the first k elements of **tr** is not equal to 'N', 'L' or 'S'.

ifail $= 4$

On entry, one or more of the elements of **z** is invalid, for the transformation requested; that is, you may be trying to log or square root a series, some of whose values are negative.

7 Accuracy

The computations are believed to be stable.

8 Further Comments

The same differencing operator does not have to be applied to all the series. For example, suppose we have $k = 2$, and wish to apply the second-order differencing operator ∇^2 to the first series and the first-order differencing operator ∇ to the second series:

$$w_{1t} = \nabla^2 z_{1t} = (1 - B)^2 z_{1t} = \left(1 - 2B + B^2\right) z_{1t}, \qquad \text{and}$$

$$w_{2t} = \nabla z_{2t} = (1 - B) z_{2t}.$$

Then $d_1 = 2, d_2 = 1$, $d = \max(d_1, d_2) = 2$, and

$$\mathbf{delta} = \begin{bmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \end{bmatrix} = \begin{bmatrix} 2 & -1 \\ 1 & \end{bmatrix}.$$

9 Example

```
z = [-1.49, -1.62, 5.2, 6.23, 6.21, 5.86, 4.09, 3.18, 2.62, 1.49, 1.17,
...
    0.85, -0.35, 0.24, 2.44, 2.58, 2.04, 0.4, 2.26, 3.34, 5.09, 5, 4.78,
...
     4.11, 3.45, 1.65, 1.29, 4.09, 6.32, 7.5, 3.89, 1.58, 5.21, 5.25,
4.93, ...
    7.38, 5.87, 5.81, 9.68, 9.07, 7.29, 7.84, 7.55, 7.32, 7.97, 7.76, 7,
8.35;
     7.34, 6.35, 6.96, 8.539999999999999, 6.62, 4.97, 4.55, 4.81, 4.75,
...
    4.76, 10.88, 10.01, 11.62, 10.36, 6.4, 6.24, 7.93, 4.04, 3.73, 5.6,
...
    5.35, 6.81, 8.27, 7.68, 6.65, 6.08, 10.25, 9.140000000000001, 17.75,
13.3, ...
    9.630000000000001, 6.8, 4.08, 5.06, 4.94, 6.65, 7.94, 10.76, 11.89,
...
      5.85, 9.01, 7.5, 10.02, 10.38, 8.15, 8.369999999999999, 10.73,
```

```
12.14];
tr = {'N'; 'N'};
id = [int32(1);
     int32(1)];
delta = [1;
     1;
     0];
[w, nd, ifail] = g13dl(z, tr, id, delta)
```

```
w =
  Columns 1 through 7
   -0.1300    6.8200    1.0300   -0.0200   -0.3500   -1.7700   -0.9100
   -0.9900    0.6100    1.5800   -1.9200   -1.6500   -0.4200    0.2600
  Columns 8 through 14
   -0.5600   -1.1300   -0.3200   -0.3200   -1.2000    0.5900    2.2000
   -0.0600    0.0100    6.1200   -0.8700    1.6100   -1.2600   -3.9600
  Columns 15 through 21
    0.1400   -0.5400   -1.6400    1.8600    1.0800    1.7500   -0.0900
   -0.1600    1.6900   -3.8900   -0.3100    1.8700   -0.2500    1.4600
  Columns 22 through 28
   -0.2200   -0.6700   -0.6600   -1.8000   -0.3600    2.8000    2.2300
    1.4600   -0.5900   -1.0300   -0.5700    4.1700   -1.1100    8.6100
  Columns 29 through 35
    1.1800   -3.6100   -2.3100    3.6300    0.0400   -0.3200    2.4500
   -4.4500   -3.6700   -2.8300   -2.7200    0.9800   -0.1200    1.7100
  Columns 36 through 42
   -1.5100   -0.0600    3.8700   -0.6100   -1.7800    0.5500   -0.2900
    1.2900    2.8200    1.1300   -6.0400    3.1600   -1.5100    2.5200
  Columns 43 through 47
   -0.2300    0.6500   -0.2100   -0.7600    1.3500
    0.3600   -2.2300    0.2200    2.3600    1.4100
nd =
          47
ifail =
           0
```