NAG Fortran Library Routine Document

G13AUF

Note: before using this routine, please read the Users' Note for your implementation to check the interpretation of ***bold italicised*** terms and other implementation-dependent details.

1 Purpose

G13AUF calculates the range (or standard deviation) and the mean for groups of successive time series values. It is intended for use in the construction of range-mean plots.

2 Specification

```
SUBROUTINE G13AUF(N, Z, M, NGRPS, RS, Y, MEAN, IFAIL)
INTEGER           N, M, NGRPS, IFAIL
real              Z(N), Y(NGRPS), MEAN(NGRPS)
CHARACTER*1       RS
```

3 Description

Let $Z_1, Z_2, \ldots, Z_n$ denote n successive observations in a time series. The series may be divided into groups of m successive values and for each group the range or standard deviation (depending on a user-supplied option) and the mean are calculated. If n is not a multiple of m then groups of equal size m are found starting from the end of the series of observations provided, and any remaining observations at the start of the series are ignored. The number of groups used, k, is the integer part of n/m. If the user wishes to ensure that no observations are ignored then the number of observations, n, should be chosen so that n is divisible by m.

The mean, M_i, the range, R_i, and the standard deviation, S_i, for the ith group are defined as

$$M_i = \frac{1}{m}\sum_{j=1}^{m} Z_{l+m(i-1)+j}$$

$$R_i = \max_{1\le j\le m}\{Z_{l+m(i-1)+j}\} - \min_{1\le j\le m}\{Z_{l+m(i-1)+j}\}$$

and

$$S_i = \sqrt{\left(\frac{1}{m-1}\right)\sum_{j=1}^{m}(Z_{l+m(i-1)+j} - M_i)^2}$$

where $l = n - km$, the number of observations ignored.

For seasonal data it is recommended that m should be equal to the seasonal period. For nonseasonal data the recommended group size is 8.

A plot of range against mean or of standard deviation against mean is useful for finding a transformation of the series which makes the variance constant. If the plot appears random or the range (or standard deviation) seems to be constant irrespective of the mean level then this suggests that no transformation of the time series is called for. On the other hand an approximate linear relationship between range (or standard deviation) and mean would indicate that a log transformation is appropriate. Further details may be found in either Jenkins (1979) or McLeod (1982).

The user has the choice of whether to use the range or the standard deviation as a measure of variability. If the group size is small they are both equally good but if the group size is fairly large (e.g., $m = 12$ for monthly data) then the range may not be as good an estimate of variability as the standard deviation.

4 References

Jenkins G M (1979) *Practical Experiences with Modelling and Forecasting Time Series* GJP Publications, Lancaster

McLeod G (1982) *Box–Jenkins in Practice. 1: Univariate Stochastic and Single Output Transfer Function/ Noise Analysis* GJP Publications, Lancaster

5 Parameters

1: N – INTEGER *Input*

On entry: the number of observations in the time series, n.

Constraint: N $\geq$ M.

2: Z(N) – ***real*** array *Input*

On entry: Z(t) must contain the tth observation Z_t, for $t = 1, 2, \ldots, n$.

3: M – INTEGER *Input*

On entry: the group size, m.

Constraint: M ≥ 2.

4: NGRPS – INTEGER *Input*

On entry: the number of groups, k.

Constraint: NGRPS = INT(N/M).

5: RS – CHARACTER*1 *Input*

On entry: indicates whether ranges or standard deviations are to be calculated.

If RS = 'R', then ranges are calculated.

If RS = 'S', then standard deviations are calculated.

Constraint: RS = 'R' or 'S'.

6: Y(NGRPS) – ***real*** array *Output*

On exit: Y(i) contains the range or standard deviation, as determined by RS, of the ith group of observations, for $i = 1, 2, \ldots, k$.

7: MEAN(NGRPS) – ***real*** array *Output*

On exit: MEAN(i) contains the mean of the ith group of observations for $i = 1, 2, \ldots, k$.

8: IFAIL – INTEGER *Input/Output*

On entry: IFAIL must be set to 0, -1 or 1. Users who are unfamiliar with this parameter should refer to Chapter P01 for details.

On exit: IFAIL = 0 unless the routine detects an error (see Section 6).

For environments where it might be inappropriate to halt program execution when an error is detected, the value -1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, for users not familiar with this parameter the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**

6 Error Indicators and Warnings

If on entry IFAIL $= 0$ or -1, explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

IFAIL $= 1$

On entry, N $<$ M,
or M < 2,
or NGRPS $\neq$ integer part of N/M.

IFAIL $= 2$

On entry, RS is not equal to 'R' or 'S'.

7 Accuracy

The computations are believed to be stable.

8 Further Comments

The time taken by the routine is approximately proportional to n.

If the user wishes to obtain a plot of the group ranges or standard deviations against the group means then G01AGF may be used. The plot is output to the unit defined by X04ABF. The user should note that G01AGF sorts the data to be plotted on the y axis (in this case the ranges or standard deviations). If required the user may use M01EAF to re-arrange the data into their original order.

9 Example

The following program produces a range-mean plot for a series of 100 observations divided into groups of 8.

9.1 Program Text

Note: the listing of the example program presented below uses ***bold italicised*** terms to denote precision-dependent details. Please read the Users' Note for your implementation to check the interpretation of these terms. As explained in the Essential Introduction to this manual, the results produced may not be identical for all implementations.

```
*     G13AUF Example Program Text
*     Mark 14 Release.  NAG Copyright 1989.
*     .. Parameters ..
      INTEGER          NIN, NOUT
      PARAMETER        (NIN=5,NOUT=6)
      INTEGER          NMAX, KMAX
      PARAMETER        (NMAX=100,KMAX=NMAX/2)
*     .. Local Scalars ..
      INTEGER          I, IFAIL, K, M, N, NSTEPX, NSTEPY
*     .. Local Arrays ..
      real             MEAN(KMAX), RANGE(KMAX), Z(NMAX)
      INTEGER          ISORT(KMAX)
*     .. External Subroutines ..
      EXTERNAL         G01AGF, G13AUF, X04ABF
*     .. Executable Statements ..
      WRITE (NOUT,*) 'G13AUF Example Program Results'
*     Skip heading in data file
      READ (NIN,*)
      CALL X04ABF(1,NOUT)
      READ (NIN,*) N, M
      IF (N.GE.M .AND. N.LE.NMAX .AND. M.GE.1) THEN
         READ (NIN,*) (Z(I),I=1,N)
         WRITE (NOUT,*)
         WRITE (NOUT,*)
```

```
     +     '                                    Range-mean plot'
           WRITE (NOUT,*)
           K = N/M
           IFAIL = 0
*
           CALL G13AUF(N,Z,M,K,'RANGE',RANGE,MEAN,IFAIL)
*
*          Produce a scatterplot of range against mean or standard
*          deviation against mean.
           NSTEPX = 60
           NSTEPY = 35
*
           CALL G01AGF(MEAN,RANGE,K,ISORT,NSTEPX,NSTEPY,IFAIL)
*
         END IF
         STOP
         END
```

9.2 Program Data

```
G13AUF Example Program Data
100 8  : N, no. of obs in time series, M, no. of obs in each group
 101  82  66  35  31   6  20  90 154 125
  85  68  38  23  10  24  83 133 131 118
  90  67  60  47  41  21  16   6   4   7
  14  34  45  43  49  42  28  10   5   2
   0   1   3  12  14  35  47  41  30  24
  16   7   4   2   8  13  36  50  62  67
  72  48  29   8  13  57 122 139 103  86
  63  37  26  11  15  40  62  98 124  96
  65  64  54  39  21   7   4  23  53  94
  96  77  59  44  47  30  16   7  37  74 : End of time series
```

9.3 Program Results

```
G13AUF Example Program Results
```