NAG Toolbox for MATLAB

g05rb

1 Purpose

g05rb sets up a reference vector and generates an array of pseudo-random numbers from a Student's t copula with ν degrees of freedom and covariance matrix $\frac{\nu}{\nu-2}C$.

2 Syntax

```
[x, iseed, r, ifail] = g05rb(mode, df, c, n, igen, iseed, r, 'm', m, 'lr', lr)
```

3 Description

The Student's t copula, c, is defined by

$$c(u_1, u_2, \cdots, u_m; C) = T^m_{\nu,C}\left(t^{-1}_{\nu,C_{11}}(u_1), t^{-1}_{\nu,C_{22}}(u_2), \cdots, t^{-1}_{\nu,C_{mm}}(u_m)\right)$$

where m is the number of dimensions, $T^m_{\nu,C}$ is the multivariate Student's t density function with ν degrees of freedom, mean zero and covariance matrix $\frac{\nu}{\nu-2}C$ and $t^{-1}_{\nu,C_{ii}}$ is the inverse of the univariate Student's t density function with ν degrees of freedom, zero mean and variance $\frac{\nu}{\nu-2}C_{ii}$.

Routine g05lx is used to generate a vector from a multivariate Student's t distribution and function g01eb is used to convert each element of that vector into a uniformly distributed value between zero and one.

One of the initialization functions g05kb (for a repeatable sequence if computed sequentially) or g05kc (for a non-repeatable sequence) must be called prior to the first call to g05rb.

4 References

Nelsen R B 1998 *An Introduction to Copulas. Lecture Notes in Statistics 139* Springer

Sklar A 1973 Random Variables: Joint Distribution Functions and Copulas *Kybernetika* **9** 499–460

5 Parameters

5.1 Compulsory Input Parameters

1: **mode – int32 scalar**

Selects the operation to be performed:

mode $= 0$

Initialize and generate random numbers.

mode $= 1$

Initialize only (i.e., set up reference vector).

mode $= 2$

Generate random numbers using previously set up reference vector.

Constraint: $0 \leq$ **mode** ≤ 2.

2: **df – int32 scalar**

ν, the number of degrees of freedom of the distribution.

Constraint: **df** ≥ 3.

3: **c(ldc,m) – double array**

ldc, the first dimension of the array, must be at least **m**.

Matrix which, along with **df** defines the covariance of the distribution. Only the upper triangle need be set.

4: **n – int32 scalar**

n, the number of random variates required.

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

5: **igen – int32 scalar**

Must contain the identification number for the generator to be used to return a pseudo-random number and should remain unchanged following initialization by a prior call to g05kb or g05kc.

6: **iseed(4) – int32 array**

Contains values which define the current state of the selected generator.

7: **r(lr) – double array**

If **mode** $= 2$, the reference vector as set up by g05rb in a previous call with **mode** $= 0$ or 1.

5.2 Optional Input Parameters

1: **m – int32 scalar**

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

m, the number of dimensions of the distribution.

Constraint: $\mathbf{m} > 0$.

2: **lr – int32 scalar**

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

If **mode** $= 2$, it must be the same as the value of **lr** specified in the prior call to g05rb with **mode** $= 0$ or 1.

Constraint: $\mathbf{lr} > \mathbf{m}(\mathbf{m}+1)+1$.

5.3 Input Parameters Omitted from the MATLAB Interface

ldc, ldx

5.4 Output Parameters

1: **x(ldx,m) – double array**

The array of pseudo-random multivariate Student's *t* vectors generated by the function.

2: **iseed(4) – int32 array**

Contains updated values defining the new state of the selected generator.

3: **r(lr) – double array**

If **mode** $= 0$ or 1, the reference vector that can be used in subsequent calls to g05rb with **mode** $= 2$.

4: **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, **mode** $\neq 0$, 1 or 2.

ifail $= 2$

On entry, **df** ≤ 2.

ifail $= 3$

On entry, **m** < 1.

ifail $= 4$

The covariance matrix **c** is not positive semi-definite to ***machine precision***.

ifail $= 5$

On entry, **ldc** $<$ **m**.

ifail $= 6$

On entry, **n** < 1.

ifail $= 8$

On entry, **ldx** $<$ **n**.

ifail $= 9$

On entry, invalid value for **igen**. **igen** must be the same as the value as specified in the prior call to g05rb with **mode** $= 0$ or 1.

ifail $= 11$

The reference vector **r** has been corrupted or **m** has changed since **r** was set up in a previous call with **mode** $= 0$ or 1.

ifail $= 12$

On entry, **lr** $<$ **m**$($**m** $+ 1)$.

7 Accuracy

See Section 7 of the document for g05lx for an indication of the accuracy of the underlying multivariate *t*-distribution.

8 Further Comments

None.

9 Example

```
mode = int32(0);
df = int32(10);
c = [1.69, 0.39, -1.86, 0.07000000000000001;
     0, 98.01000000000001, -7.07, -0.71;
     0, 0, 11.56, 0.03;
```

```
     0, 0, 0, 0.01];
n = int32(10);
igen = int32(1);
iseed = [int32(1762543);
     int32(9324783);
     int32(42344);
     int32(742355)];
r = zeros(32, 1);
[x, iseedOut, rOut, ifail] = g05rb(mode, df, c, n, igen, iseed, r)
```

```
x =
    0.9313    0.2383    0.1422    0.8744
    0.2680    0.6898    0.5245    0.1360
    0.4794    0.8201    0.8374    0.4155
    0.1090    0.4704    0.7063    0.2704
    0.4188    0.1213    0.8052    0.7113
    0.5303    0.8660    0.4552    0.2842
    0.2386    0.3615    0.9266    0.5123
    0.7943    0.7209    0.0093    0.3239
    0.8986    0.0743    0.5648    0.9152
    0.2385    0.0333    0.8660    0.8669
iseedOut =
     4474539
     9882971
     9948242
     5842803
rOut =
    4.5000
    1.3000
    0.3000
   -1.4308
    0.0538
         0
    9.8955
   -0.6711
   -0.0734
         0
         0
    3.0104
    0.0192
         0
         0
         0
    0.0367
    1.3000
    9.9000
    3.4000
    0.1000
   10.0000
         0
         0
         0
         0
         0
         0
         0
         0
         0
         0
ifail =
           0
```