

## nag\_real\_cholesky (f03aec)

### 1. Purpose

**nag\_real\_cholesky (f03aec)** computes a Cholesky factorization of a real symmetric positive-definite matrix, and evaluates the determinant.

### 2. Specification

```
#include <nag.h>
#include <nagf03.h>

void nag_real_cholesky(Integer n, double a[], Integer tda, double p[],
    double *detf, Integer *dete, NagError *fail)
```

### 3. Description

This function computes the Cholesky factorization of a real symmetric positive-definite matrix  $A = LL^T$  where  $L$  is lower triangular. The determinant is the product of the squares of the diagonal elements of  $L$ .

### 4. Parameters

**n**

Input:  $n$ , the order of the matrix  $A$ .  
Constraint:  $n \geq 1$ .

**a[n][tda]**

Input: the upper triangle of the  $n$  by  $n$  positive-definite symmetric matrix  $A$ . The elements of the array below the diagonal need not be set.  
Output: the sub-diagonal elements of the lower triangular matrix  $L$ . The upper triangle of  $A$  is unchanged.

**tda**

Input: the second dimension of the array **a** as declared in the function from which **nag\_real\_cholesky** is called.  
Constraint: **tda**  $\geq$  **n**.

**p[n]**

Output: the reciprocals of the diagonal elements of  $L$ .

**detf**

**dete**

Output: the determinant of  $A$  is given by **detf**  $\times$   $2.0^{\text{dete}}$ . It is given in this form to avoid overflow or underflow.

**fail**

The NAG error parameter, see the Essential Introduction to the NAG C Library.

### 5. Error Indications and Warnings

**NE\_NOT\_POS\_DEF**

The matrix is not positive-definite, possibly due to rounding errors. The factorization could not be completed. **detf** and **dete** are set to zero.

**NE\_INT\_ARG\_LT**

On entry, **n** must not be less than 1: **n** = *<value>*.

**NE\_2\_INT\_ARG\_LT**

On entry, **tda** = *<value>* while **n** = *<value>*. These parameters must satisfy **tda**  $\geq$  **n**.

### 6. Further Comments

The time taken by the function is approximately proportional to  $n^3$ .

### 6.1. Accuracy

The accuracy of the determinant depends on the conditioning of the original matrix. For a detailed error analysis see Wilkinson and Reinsch (1971) p 25.

### 6.2. References

Wilkinson J H and Reinsch C (1971) *Handbook for Automatic Computation (Vol II, Linear Algebra)* Springer-Verlag pp 9–30.

### 7. See Also

nag\_real\_cholesky\_solve\_mult\_rhs (f04agc)

### 8. Example

To compute a Cholesky factorization and calculate the determinant of the real symmetric positive-definite matrix

$$\begin{pmatrix} 6 & 7 & 6 & 5 \\ 7 & 11 & 8 & 7 \\ 6 & 8 & 11 & 9 \\ 5 & 7 & 9 & 11 \end{pmatrix}.$$

#### 8.1. Program Text

```

/* nag_real_cholesky(f03aec) Example Program
 *
 * Copyright 1990 Numerical Algorithms Group.
 *
 * Mark 1, 1990.
 */

#include <nag.h>
#include <math.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagf03.h>

#define NMAX 8
#define TDA NMAX

main()
{
    double detf, determ, a[NMAX][TDA], p[NMAX];
    Integer i, dete, j, n;
    static NagError fail;

    Vprintf("f03aec Example Program Results\n");
    /* Skip heading in data file */
    Vscanf("%*[^\\n]");
    Vscanf("%ld\\n",&n);
    if (n<1 || n>NMAX)
    {
        Vfprintf(stderr,"n is out of range: n = %5ld\\n",n);
        exit(EXIT_FAILURE);
    }
    for (i=0; i<n; i++)
        for (j=0; j<n; j++)
            Vscanf("%lf",&a[i][j]);
    fail.print = TRUE;
    f03aec(n, (double *)a, (Integer)TDA, p, &detf, &dete, &fail);
    if (fail.code != NE_NOERROR)
        exit(EXIT_FAILURE);
    Vprintf("Array A after factorization\n");
    for (i=0; i<n; i++)
        for (j=0; j<n; j++)
            Vprintf("%9.4f%s", a[i][j], (j%8==7 || j==n-1) ? "\\n" : " ");

```

```

Vprintf("\nArray p\n");
for (i=0; i<n; i++)
    Vprintf("%9.4f%s", p[i], (i%8==7 || i==n-1) ? "\n" : " ");
Vprintf("\ndetf = %9.4f      dete = %2ld\n\n", detf, dete);
determ = detf*pow(2.0,(double)dete);
Vprintf("Value of determinant = %9.4f\n", determ);
exit(EXIT_SUCCESS);
}

```

## 8.2. Program Data

f03aec Example Program Data

```

4
 6   7   6   5
 7  11   8   7
 6   8  11   9
 5   7   9  11

```

## 8.3. Program Results

f03aec Example Program Results

Array A after factorization

6.0000	7.0000	6.0000	5.0000
2.8577	11.0000	8.0000	7.0000
2.4495	0.5941	11.0000	9.0000
2.0412	0.6931	1.6645	11.0000

Array p

0.4082	0.5941	0.4639	0.5283
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detf = 0.0691                      dete = 12

Value of determinant = 283.0000

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