NAG C Library Function Document

nag_dtrtri (f07tjc)

1 Purpose

nag_dtrtri (f07tjc) computes the inverse of a real triangular matrix.

2 Specification

```
void nag_dtrtri (Nag_OrderType order, Nag_UploType uplo, Nag_DiagType diag,
     Integer n, double a[], Integer pda, NagError *fail)
```

3 Description

nag_dtrtri (f07tjc) forms the inverse of a real triangular matrix A. Note that the inverse of an upper (lower) triangular matrix is also upper (lower) triangular.

4 References

Du Croz J J and Higham N J (1992) Stability of methods for matrix inversion *IMA J. Numer. Anal.* **12** 1–19

5 Parameters

1: **order** – Nag_OrderType *Input*

On entry: the **order** parameter specifies the two-dimensional storage scheme being used, i.e., row-major ordering or column-major ordering. C language defined storage is specified by **order** = **Nag_RowMajor**. See Section 2.2.1.4 of the Essential Introduction for a more detailed explanation of the use of this parameter.

Constraint: **order** = **Nag_RowMajor** or **Nag_ColMajor**.

2: **uplo** – Nag_UploType *Input*

On entry: indicates whether A is upper or lower triangular as follows:

if **uplo** = **Nag_Upper**, A is upper triangular;

if **uplo** = **Nag_Lower**, A is lower triangular.

Constraint: **uplo** = **Nag_Upper** or **Nag_Lower**.

3: **diag** – Nag_DiagType *Input*

On entry: indicates whether A is a non-unit or unit triangular matrix as follows:

if **diag** = **Nag_NonUnitDiag**, A is a non-unit triangular matrix;

if **diag** = **Nag_UnitDiag**, A is a unit triangular matrix; the diagonal elements are not referenced and are assumed to be 1.

Constraint: **diag** = **Nag_NonUnitDiag** or **Nag_UnitDiag**.

4: **n** – Integer *Input*

On entry: n, the order of the matrix A.

Constraint: **n** ≥ 0.

5: **a**[dim] – double *Input/Output*

Note: the dimension, dim, of the array **a** must be at least $\max(1, \mathbf{pda} \times \mathbf{n})$.

If **order** = **Nag_ColMajor**, the (i, j)th element of the matrix A is stored in $\mathbf{a}[(j-1) \times \mathbf{pda} + i - 1]$ and if **order** = **Nag_RowMajor**, the (i, j)th element of the matrix A is stored in $\mathbf{a}[(i-1) \times \mathbf{pda} + j - 1]$.

On entry: the n by n triangular matrix A. If **uplo** = **Nag_Upper**, A is upper triangular and the elements of the array below the diagonal are not referenced; if **uplo** = **Nag_Lower**, A is lower triangular and the elements of the array above the diagonal are not referenced. If **diag** = **Nag_UnitDiag**, the diagonal elements of A are not referenced, but are assumed to be 1.

On exit: A is overwritten by A^{-1}, using the same storage format as described above.

6: **pda** – Integer *Input*

On entry: the stride separating row or column elements (depending on the value of **order**) of the matrix A in the array **a**.

Constraint: $\mathbf{pda} \geq \max(1, \mathbf{n})$.

7: **fail** – NagError * *Output*

The NAG error parameter (see the Essential Introduction).

6 Error Indicators and Warnings

NE_INT

On entry, $\mathbf{n} = \langle value \rangle$.
Constraint: $\mathbf{n} \geq 0$.

On entry, $\mathbf{pda} = \langle value \rangle$.
Constraint: $\mathbf{pda} > 0$.

NE_INT_2

On entry, $\mathbf{pda} = \langle value \rangle$, $\mathbf{n} = \langle value \rangle$.
Constraint: $\mathbf{pda} \geq \max(1, \mathbf{n})$.

NE_SINGULAR

$a(\langle value \rangle, \langle value \rangle)$ is zero, and the matrix A is singular.

NE_ALLOC_FAIL

Memory allocation failed.

NE_BAD_PARAM

On entry, parameter $\langle value \rangle$ had an illegal value.

NE_INTERNAL_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please consult NAG for assistance.

7 Accuracy

The computed inverse X satisfies

$$|XA - I| \leq c(n)\epsilon|X|\,|A|,$$

where $c(n)$ is a modest linear function of n, and ϵ is the ***machine precision***.

Note that a similar bound for $|AX - I|$ cannot be guaranteed, although it is almost always satisfied.

The computed inverse satisfies the forward error bound

$$|X - A^{-1}| \leq c(n)\epsilon|A^{-1}|\,|A|\,|X|.$$

See Du Croz and Higham (1992).

8 Further Comments

The total number of floating-point operations is approximately $\frac{1}{3}n^3$.

The complex analogue of this function is nag_ztrtri (f07twc).

9 Example

To compute the inverse of the matrix A, where

$$A = \begin{pmatrix} 4.30 & 0.00 & 0.00 & 0.00 \\ -3.96 & -4.87 & 0.00 & 0.00 \\ 0.40 & 0.31 & -8.02 & 0.00 \\ -0.27 & 0.07 & -5.95 & 0.12 \end{pmatrix}.$$

9.1 Program Text

```
/* nag_dtrtri (f07tjc) Example Program.
 *
 * Copyright 2001 Numerical Algorithms Group.
 *
 * Mark 7, 2001.
 */

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagf07.h>
#include <nagx04.h>

int main(void)
{
  /* Scalars */
  Integer i, j, n, pda;
  Integer exit_status=0;
  Nag_UploType uplo_enum;
  Nag_MatrixType matrix;

  NagError fail;
  Nag_OrderType order;
  /* Arrays */
  char   uplo[2];
  double *a=0;

#ifdef NAG_COLUMN_MAJOR
#define A(I,J) a[(J-1)*pda + I - 1]
  order = Nag_ColMajor;
#else
#define A(I,J) a[(I-1)*pda + J - 1]
  order = Nag_RowMajor;
#endif

  INIT_FAIL(fail);
  Vprintf("f07tjc Example Program Results\n\n");
  /* Skip heading in data file */
  Vscanf("%*[^\n] ");
  Vscanf("%ld%*[^\n] ", &n);
#ifdef NAG_COLUMN_MAJOR
  pda = n;
#else
  pda = n;
```

```
#endif
  /* Allocate memory */
  if ( !(a = NAG_ALLOC(n * n, double)) )
    {
      Vprintf("Allocation failure\n");
      exit_status = -1;
      goto END;
    }
  /* Read A from data file */
  Vscanf(" ' %1s '%*[^\n] ", uplo);
  if (*(unsigned char *)uplo == 'L')
    {
      uplo_enum = Nag_Lower;
      matrix = Nag_LowerMatrix;
    }
  else if (*(unsigned char *)uplo == 'U')
    {
      uplo_enum = Nag_Upper;
      matrix = Nag_UpperMatrix;
    }
  else
    {
      Vprintf("Unrecognised character for Nag_UploType type\n");
      exit_status = -1;
      goto END;
    }
  if (uplo_enum == Nag_Upper)
    {
      for (i = 1; i <= n; ++i)
        {
          for (j = i; j <= n; ++j)
            Vscanf("%lf", &A(i,j));
        }
      Vscanf("%*[^\n] ");
    }
  else
    {
      for (i = 1; i <= n; ++i)
        {
          for (j = 1; j <= i; ++j)
            Vscanf("%lf", &A(i,j));
        }
      Vscanf("%*[^\n] ");
    }

  /* Compute inverse of A */
  f07tjc(order, uplo_enum, Nag_NonUnitDiag, n, a, pda, &fail);
  if (fail.code != NE_NOERROR)
    {
      Vprintf("Error from f07tjc.\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }

  /* Print inverse */
  x04cac(order, matrix, Nag_NonUnitDiag, n, n, a, pda,
         "Inverse", 0, &fail);
  if (fail.code != NE_NOERROR)
    {
      Vprintf("Error from x04cac.\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }
 END:
  if (a) NAG_FREE(a);

  return exit_status;
}
```

9.2 Program Data

```
f07tjc Example Program Data
  4                           :Value of N
  'L'                         :Value of UPLO
  4.30
 -3.96  -4.87
  0.40   0.31  -8.02
 -0.27   0.07  -5.95   0.12   :End of matrix A
```

9.3 Program Results

```
f07tjc Example Program Results

 Inverse
             1           2           3           4
 1      0.2326
 2     -0.1891     -0.2053
 3      0.0043     -0.0079     -0.1247
 4      0.8463     -0.2738     -6.1825      8.3333
```