

## NAG C Library Function Document

### nag\_dpptri (f07gjc)

#### 1 Purpose

nag\_dpptri (f07gjc) computes the inverse of a real symmetric positive-definite matrix  $A$ , where  $A$  has been factorized by nag\_dpptrf (f07gdc), using packed storage.

#### 2 Specification

```
void nag_dpptri (Nag_OrderType order, Nag_UploType uplo, Integer n, double ap[],
                NagError *fail)
```

#### 3 Description

To compute the inverse of a real symmetric positive-definite matrix  $A$ , this function must be preceded by a call to nag\_dpptrf (f07gdc), which computes the Cholesky factorization of  $A$  using packed storage.

If **uplo** = **Nag\_Upper**,  $A = U^T U$  and  $A^{-1}$  is computed by first inverting  $U$  and then forming  $(U^{-1})(U^{-1})^T$ .

If **uplo** = **Nag\_Lower**,  $A = L L^T$  and  $A^{-1}$  is computed by first inverting  $L$  and then forming  $(L^{-1})^T(L^{-1})$ .

#### 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  $A$  has been factorized as  $U^T U$  or  $L L^T$  as follows:

if **uplo** = **Nag\_Upper**,  $A = U^T U$ , where  $U$  is upper triangular;

if **uplo** = **Nag\_Lower**,  $A = L L^T$ , where  $L$  is lower triangular.

*Constraint:* **uplo** = **Nag\_Upper** or **Nag\_Lower**.

3: **n** – Integer *Input*

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

*Constraint:*  $n \geq 0$ .

4: **ap**[*dim*] – double *Input/Output*

**Note:** the dimension, *dim*, of the array **ap** must be at least  $\max(1, n \times (n + 1)/2)$ .

*On entry:* the upper triangular matrix  $U$  stored in packed form if **uplo** = **Nag\_Upper** or the lower triangular matrix  $L$  stored in packed form if **uplo** = **Nag\_Lower**, as returned by nag\_dpptf (f07gdc).

*On exit:*  $U$  is overwritten by the upper triangle of  $A^{-1}$  if **uplo** = **Nag\_Upper**;  $L$  is overwritten by the lower triangle of  $A^{-1}$  if **uplo** = **Nag\_Lower**, using the same storage scheme as on entry.

- 5: **fail** – NagError \* *Output*  
 The NAG error parameter (see the Essential Introduction).

## 6 Error Indicators and Warnings

### NE\_INT

On entry, **n** =  $\langle value \rangle$ .  
 Constraint: **n**  $\geq 0$ .

### NE\_SINGULAR

Element  $\langle value \rangle$  of the diagonal of the Cholesky factor is zero. The Cholesky factor is singular, and the inverse of  $A$  cannot be computed.

### 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

$$\|XA - I\|_2 \leq c(n)\epsilon\kappa_2(A) \quad \text{and} \quad \|AX - I\|_2 \leq c(n)\epsilon\kappa_2(A),$$

where  $c(n)$  is a modest function of  $n$ ,  $\epsilon$  is the *machine precision* and  $\kappa_2(A)$  is the condition number of  $A$  defined by

$$\kappa_2(A) = \|A\|_2 \|A^{-1}\|_2.$$

## 8 Further Comments

The total number of floating-point operations is approximately  $\frac{2}{3}n^3$ .

The complex analogue of this function is nag\_zpptf (f07gwc).

## 9 Example

To compute the inverse of the matrix  $A$ , where

$$A = \begin{pmatrix} 4.16 & -3.12 & 0.56 & -0.10 \\ -3.12 & 5.03 & -0.83 & 1.18 \\ 0.56 & -0.83 & 0.76 & 0.34 \\ -0.10 & 1.18 & 0.34 & 1.18 \end{pmatrix}.$$

Here  $A$  is symmetric positive-definite, stored in packed form, and must first be factorized by nag\_dpptf (f07gdc).

## 9.1 Program Text

```

/* nag_dpptri (f07gjc) 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 ap_len, i, j, n;
    Integer exit_status=0;
    NagError fail;
    Nag_UploType uplo_enum;
    Nag_OrderType order;

    /* Arrays */
    char uplo[2];
    double *ap=0;

#ifdef NAG_COLUMN_MAJOR
#define A_UPPER(I,J) ap[J*(J-1)/2 + I - 1]
#define A_LOWER(I,J) ap[(2*n-J)*(J-1)/2 + I - 1]
    order = Nag_ColMajor;
#else
#define A_LOWER(I,J) ap[I*(I-1)/2 + J - 1]
#define A_UPPER(I,J) ap[(2*n-I)*(I-1)/2 + J - 1]
    order = Nag_RowMajor;
#endif

    INIT_FAIL(fail);
    Vprintf("f07gjc Example Program Results\n\n");

    /* Skip heading in data file */
    Vscanf("%*[^\\n] ");
    Vscanf("%ld%*[^\\n] ", &n);
    ap_len = n * (n + 1)/2;

    /* Allocate memory */
    if ( !(ap = NAG_ALLOC(ap_len, 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;
    else if (*(unsigned char *)uplo == 'U')
        uplo_enum = Nag_Upper;
    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_UPPER(i,j));
        }
        Vscanf("%*[\n] ");
    }
else
    {
        for (i = 1; i <= n; ++i)
        {
            for (j = 1; j <= i; ++j)
                Vscanf("%lf", &A_LOWER(i,j));
        }
        Vscanf("%*[\n] ");
    }

/* Factorize A */
f07gdc(order, uplo_enum, n, ap, &fail);
if (fail.code != NE_NOERROR)
    {
        Vprintf("Error from f07gdc.\n%s\n", fail.message);
        exit_status = 1;
        goto END;
    }
/* Compute inverse of A */
f07gjc(order, uplo_enum, n, ap, &fail);
if (fail.code != NE_NOERROR)
    {
        Vprintf("Error from f07gjc.\n%s\n", fail.message);
        exit_status = 1;
        goto END;
    }
/* Print inverse */
x04ccc(order, uplo_enum, Nag_NonUnitDiag, n, ap,
        "Inverse", 0, NAGERR_DEFAULT);
if (fail.code != NE_NOERROR)
    {
        Vprintf("Error from x04ccc.\n%s\n", fail.message);
        exit_status = 1;
        goto END;
    }
END:
if (ap) NAG_FREE(ap);
return exit_status;
}

```

## 9.2 Program Data

```

f07gjc Example Program Data
  4                               :Value of N
  'L'                             :Value of UPLO
  4.16
 -3.12   5.03
  0.56  -0.83   0.76
 -0.10   1.18   0.34   1.18   :End of matrix A

```

## 9.3 Program Results

f07gjc Example Program Results

| Inverse | 1       | 2       | 3       | 4      |
|---------|---------|---------|---------|--------|
| 1       | 0.6995  |         |         |        |
| 2       | 0.7769  | 1.4239  |         |        |
| 3       | 0.7508  | 1.8255  | 4.0688  |        |
| 4       | -0.9340 | -1.8841 | -2.9342 | 3.4978 |