NAG C Library Function Document

nag_zpptri (f07gwc)

1 Purpose

nag_zpptri (f07gwc) computes the inverse of a complex Hermitian positive-definite matrix A, where A has been factorized by nag_zpptrf (f07grc), using packed storage.

2 Specification

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

3 Description

To compute the inverse of a complex Hermitian positive-definite matrix A, this function must be preceded by a call to nag_zpptrf (f07grc), which computes the Cholesky factorization of A using packed storage.

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

If **uplo** $=$ **Nag_Lower**, $A = LL^H$ and A^{-1} is computed by first inverting L and then forming $(L^{-1})^H(L^{-1})$.

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 $U^H U$ or LL^H as follows:

if **uplo** $=$ **Nag_Upper**, $A = U^H U$, where U is upper triangular;

if **uplo** $=$ **Nag_Lower**, $A = LL^H$, 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** ≥ 0.

4: **ap**$[dim]$ – Complex *Input/Output*

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

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_zpptrf (f07grc).

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** = ⟨*value*⟩.
Constraint: **n** ≥ 0.

NE_SINGULAR

Element ⟨*value*⟩ 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 ⟨*value*⟩ 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, ϵ 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 real floating-point operations is approximately $\frac{8}{3}n^3$.

The real analogue of this function is nag_dpptri (f07gjc).

9 Example

To compute the inverse of the matrix A, where

$$A = \begin{pmatrix} 3.23 + 0.00i & 1.51 - 1.92i & 1.90 + 0.84i & 0.42 + 2.50i \\ 1.51 + 1.92i & 3.58 + 0.00i & -0.23 + 1.11i & -1.18 + 1.37i \\ 1.90 - 0.84i & -0.23 - 1.11i & 4.09 + 0.00i & 2.33 - 0.14i \\ 0.42 - 2.50i & -1.18 - 1.37i & 2.33 + 0.14i & 4.29 + 0.00i \end{pmatrix}.$$

Here A is Hermitian positive-definite, stored in packed form, and must first be factorized by nag_zpptrf (f07grc).

9.1 Program Text

```
/* nag_zpptri (f07gwc) 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];
  Complex *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("f07gwc 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, Complex)) )
    {
      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 , %lf )", &A_UPPER(i,j).re, &A_UPPER(i,j).im);
        }
      Vscanf("%*[^\n] ");
    }
  else
    {
      for (i = 1; i <= n; ++i)
        {
          for (j = 1; j <= i; ++j)
            Vscanf(" ( %lf , %lf )", &A_LOWER(i,j).re, &A_LOWER(i,j).im);
        }
      Vscanf("%*[^\n] ");
    }

  /* Factorize A */
  f07grc(order, uplo_enum, n, ap, &fail);
  if (fail.code != NE_NOERROR)
    {
      Vprintf("Error from f07grc.\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }
  /* Compute inverse of A */
  f07gwc(order, uplo_enum, n, ap, &fail);
  if (fail.code != NE_NOERROR)
    {
      Vprintf("Error from f07gwc.\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }
  /* Print inverse */
  x04ddc(order, uplo_enum, Nag_NonUnitDiag, n, ap,
         Nag_BracketForm, "%7.4f", "Inverse", Nag_IntegerLabels,
         0, Nag_IntegerLabels, 0, 80, 0, 0, &fail);
  if (fail.code != NE_NOERROR)
    {
      Vprintf("Error from x04ddc.\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }
 END:
  if (ap) NAG_FREE(ap);

return exit_status;
}
```

9.2 Program Data

```
f07gwc Example Program Data
  4                                                     :Value of N
  'L'                                                   :Value of UPLO
 (3.23, 0.00)
 (1.51, 1.92) ( 3.58, 0.00)
 (1.90,-0.84) (-0.23,-1.11) ( 4.09, 0.00)
 (0.42,-2.50) (-1.18,-1.37) ( 2.33, 0.14) ( 4.29, 0.00)  :End of matrix A
```

9.3 Program Results

```
f07gwc Example Program Results

 Inverse
                    1                   2                   3                   4
 1  ( 5.4691, 0.0000)
 2  (-1.2624,-1.5491)  ( 1.1024, 0.0000)
 3  (-2.9746,-0.9616)  ( 0.8989,-0.5672)  ( 2.1589, 0.0000)
 4  ( 1.1962, 2.9772)  (-0.9826,-0.2566)  (-1.3756,-1.4550)  ( 2.2934, 0.0000)
```