

NAG Library Function Document

nag_zsptri (f07qwc)

1 Purpose

nag_zsptri (f07qwc) computes the inverse of a complex symmetric matrix A , where A has been factorized by nag_zsptf (f07qrc), using packed storage.

2 Specification

```
#include <nag.h>
#include <nagf07.h>

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

3 Description

nag_zsptri (f07qwc) is used to compute the inverse of a complex symmetric matrix A , the function must be preceded by a call to nag_zsptf (f07qrc), which computes the Bunch–Kaufman factorization of A , using packed storage.

If **uplo** = Nag_Upper, $A = PUDU^T P^T$ and A^{-1} is computed by solving $U^T P^T X P U = D^{-1}$.

If **uplo** = Nag_Lower, $A = PLDL^T P^T$ and A^{-1} is computed by solving $L^T P^T X P L = D^{-1}$.

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 Arguments

1: **order** – Nag_OrderType *Input*

On entry: the **order** argument 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 3.2.1.3 in the Essential Introduction for a more detailed explanation of the use of this argument.

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

2: **uplo** – Nag_UploType *Input*

On entry: specifies how A has been factorized.

uplo = Nag_Upper
 $A = PUDU^T P^T$, where U is upper triangular.

uplo = Nag_Lower
 $A = PLDL^T P^T$, 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*] – 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 factorization of *A* stored in packed form, as returned by nag_zsprtf (f07qrc).

On exit: the factorization is overwritten by the *n* by *n* matrix A^{-1} .

The storage of elements A_{ij} depends on the **order** and **uplo** arguments as follows:

if **order** = Nag_ColMajor and **uplo** = Nag_Upper,
 A_{ij} is stored in **ap**[(*j* – 1) × *j*/2 + *i* – 1], for $i \leq j$;
 if **order** = Nag_ColMajor and **uplo** = Nag_Lower,
 A_{ij} is stored in **ap**[(2*n* – *j*) × (*j* – 1)/2 + *i* – 1], for $i \geq j$;
 if **order** = Nag_RowMajor and **uplo** = Nag_Upper,
 A_{ij} is stored in **ap**[(2*n* – *i*) × (*i* – 1)/2 + *j* – 1], for $i \leq j$;
 if **order** = Nag_RowMajor and **uplo** = Nag_Lower,
 A_{ij} is stored in **ap**[(*i* – 1) × *i*/2 + *j* – 1], for $i \geq j$.

5: **ipiv**[*dim*] – const Integer Input

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

On entry: details of the interchanges and the block structure of *D*, as returned by nag_zsprtf (f07qrc).

6: **fail** – NagError * Input/Output

The NAG error argument (see Section 3.6 in the Essential Introduction).

6 Error Indicators and Warnings

NE_ALLOC_FAIL

Dynamic memory allocation failed.

See Section 3.2.1.2 in the Essential Introduction for further information.

NE_BAD_PARAM

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

NE_INT

On entry, $\mathbf{n} = \langle value \rangle$.

Constraint: $\mathbf{n} \geq 0$.

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 contact NAG for assistance.

An unexpected error has been triggered by this function. Please contact NAG.

See Section 3.6.6 in the Essential Introduction for further information.

NE_NO_LICENCE

Your licence key may have expired or may not have been installed correctly.

See Section 3.6.5 in the Essential Introduction for further information.

NE_SINGULAR

Element $\langle value \rangle$ of the diagonal is exactly zero. *D* is singular and the inverse of *A* cannot be computed.

7 Accuracy

The computed inverse X satisfies a bound of the form

$$\text{if } \mathbf{uplo} = \text{Nag_Upper}, |DU^T P^T X P U - I| \leq c(n)\epsilon(|D||U^T|P^T|X|P|U| + |D||D^{-1}|);$$

$$\text{if } \mathbf{uplo} = \text{Nag_Lower}, |DL^T P^T X P L - I| \leq c(n)\epsilon(|D||L^T|P^T|X|P|L| + |D||D^{-1}|),$$

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

8 Parallelism and Performance

nag_zsptri (f07qwc) is not threaded by NAG in any implementation.

nag_zsptri (f07qwc) makes calls to BLAS and/or LAPACK routines, which may be threaded within the vendor library used by this implementation. Consult the documentation for the vendor library for further information.

Please consult the X06 Chapter Introduction for information on how to control and interrogate the OpenMP environment used within this function. Please also consult the Users' Note for your implementation for any additional implementation-specific information.

9 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_dsptri (f07pjc).

10 Example

This example computes the inverse of the matrix A , where

$$A = \begin{pmatrix} -0.39 - 0.71i & 5.14 - 0.64i & -7.86 - 2.96i & 3.80 + 0.92i \\ 5.14 - 0.64i & 8.86 + 1.81i & -3.52 + 0.58i & 5.32 - 1.59i \\ -7.86 - 2.96i & -3.52 + 0.58i & -2.83 - 0.03i & -1.54 - 2.86i \\ 3.80 + 0.92i & 5.32 - 1.59i & -1.54 - 2.86i & -0.56 + 0.12i \end{pmatrix}.$$

Here A is symmetric, stored in packed form, and must first be factorized by nag_zsptf (f07qrc).

10.1 Program Text

```

/* nag_zsptri (f07qwc) Example Program.
 *
 * Copyright 2014 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;
    Nag_OrderType order;
    /* Arrays */
    Integer    *ipiv = 0;
    char       nag_enum_arg[40];
    Complex    *ap = 0;

```

```

#ifdef NAG_LOAD_FP
  /* The following line is needed to force the Microsoft linker
     to load floating point support */
  float force_loading_of_ms_float_support = 0;
#endif /* NAG_LOAD_FP */

#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);

  printf("nag_zsptri (f07qwc) Example Program Results\n\n");

  /* Skip heading in data file */
#ifdef _WIN32
  scanf_s("%*[\n] ");
#else
  scanf("%*[\n] ");
#endif
#ifdef _WIN32
  scanf_s("%"NAG_IFMT"%*[\n] ", &n);
#else
  scanf("%"NAG_IFMT"%*[\n] ", &n);
#endif
  ap_len = n * (n + 1)/2;

  /* Allocate memory */
  if (!(ipiv = NAG_ALLOC(n, Integer)) ||
      !(ap = NAG_ALLOC(ap_len, Complex)))
  {
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
  }
  /* Read A from data file */
#ifdef _WIN32
  scanf_s(" %39s%*[\n] ", nag_enum_arg, _countof(nag_enum_arg));
#else
  scanf(" %39s%*[\n] ", nag_enum_arg);
#endif
  /* nag_enum_name_to_value (x04nac).
   * Converts NAG enum member name to value
   */
  uplo = (Nag_UploType) nag_enum_name_to_value(nag_enum_arg);

  if (uplo == Nag_Upper)
  {
    for (i = 1; i <= n; ++i)
    {
      for (j = i; j <= n; ++j)
#ifdef _WIN32
        scanf_s(" ( %lf , %lf )", &A_UPPER(i, j).re,
                &A_UPPER(i, j).im);
#else
        scanf(" ( %lf , %lf )", &A_UPPER(i, j).re,
                &A_UPPER(i, j).im);
#endif
    }
  }
#ifdef _WIN32
  scanf_s("%*[\n] ");
#else
  scanf("%*[\n] ");
#endif
#endif

```

```

    }
else
    {
        for (i = 1; i <= n; ++i)
            {
                for (j = 1; j <= i; ++j)
#ifdef _WIN32
                    scanf_s(" ( %lf , %lf )", &A_LOWER(i, j).re,
                            &A_LOWER(i, j).im);
#else
                    scanf(" ( %lf , %lf )", &A_LOWER(i, j).re,
                            &A_LOWER(i, j).im);
#endifif
            }
#ifdef _WIN32
        scanf_s("%*[\n] ");
#else
        scanf("%*[\n] ");
#endifif
    }

    /* Factorize A */
    /* nag_zsptrf (f07qrc).
     * Bunch-Kaufman factorization of complex symmetric matrix,
     * packed storage
     */
    nag_zsptrf(order, uplo, n, ap, ipiv, &fail);
    if (fail.code != NE_NOERROR)
        {
            printf("Error from nag_zsptrf (f07qrc).\n%s\n", fail.message);
            exit_status = 1;
            goto END;
        }
    /* Compute inverse of A */
    /* nag_zsptri (f07qwc).
     * Inverse of complex symmetric matrix, matrix already
     * factorized by nag_zsptrf (f07qrc), packed storage
     */
    nag_zsptri(order, uplo, n, ap, ipiv, &fail);
    if (fail.code != NE_NOERROR)
        {
            printf("Error from nag_zsptri (f07qwc).\n%s\n", fail.message);
            exit_status = 1;
            goto END;
        }
    /* Print inverse */
    /* nag_pack_complx_mat_print_comp (x04ddc).
     * Print complex packed triangular matrix (comprehensive)
     */
    fflush(stdout);
    nag_pack_complx_mat_print_comp(order, uplo, Nag_NonUnitDiag, n, ap,
                                    Nag_BracketForm, "%7.4f", "Inverse",
                                    Nag_IntegerLabels, 0, Nag_IntegerLabels, 0,
                                    80, 0, 0, &fail);

    if (fail.code != NE_NOERROR)
        {
            printf("Error from nag_pack_complx_mat_print_comp (x04ddc).\n%s\n",
                    fail.message);
            exit_status = 1;
            goto END;
        }
END:
    NAG_FREE(ipiv);
    NAG_FREE(ap);

    return exit_status;
}

```

10.2 Program Data

```
nag_zsptri (f07qwc) Example Program Data
4                                     :Value of n
Nag_Lower                           :Value of uplo
(-0.39,-0.71)
( 5.14,-0.64) ( 8.86, 1.81)
(-7.86,-2.96) (-3.52, 0.58) (-2.83,-0.03)
( 3.80, 0.92) ( 5.32,-1.59) (-1.54,-2.86) (-0.56, 0.12) :End of matrix A
```

10.3 Program Results

```
nag_zsptri (f07qwc) Example Program Results

Inverse
      1          2          3          4
1 (-0.1562,-0.1014)
2 ( 0.0400, 0.1527) ( 0.0946,-0.1475)
3 ( 0.0550, 0.0845) (-0.0326,-0.1370) (-0.1320,-0.0102)
4 ( 0.2162,-0.0742) (-0.0995,-0.0461) (-0.1793, 0.1183) (-0.2269, 0.2383)
```
