NAG Library Function Document

nag_ztptri (f07uwc)

1 Purpose

nag_ztptri (f07uwc) computes the inverse of a complex triangular matrix, using packed storage.

2 Specification

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

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

3 Description

nag_ztptri (f07uwc) forms the inverse of a complex triangular matrix $A$, using packed storage. Note that the inverse of an upper (lower) triangular matrix is also upper (lower) triangular.

4 References


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 whether $A$ is upper or lower triangular.
    
    `uplo = Nag_Upper`
    
    $A$ is upper triangular.
    
    `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 nonunit or unit triangular matrix.
    
    `diag = Nag_NonUnitDiag`
    
    $A$ is a nonunit triangular matrix.
    
    `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`. 

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4: \( n \) – Integer
   \( \text{Input} \)
   \( \text{On entry: } n \), the order of the matrix \( A \).
   \( \text{Constraint: } n \geq 0. \)

5: \( \text{ap[dim]} \) – Complex
   \( \text{Input/Output} \)
   \( \text{Note: the dimension, } \dim, \text{ of the array } \text{ap} \text{ must be at least max}(1, n \times (n + 1)/2). \)
   \( \text{On entry: } n \text{ by } n \text{ triangular matrix } A, \text{ packed by rows or columns.} \)
   The storage of elements \( A_{ij} \) depends on the \( \text{order} \) and \( \text{uplo} \) arguments as follows:
   
   if \( \text{order} = \text{Nag\_ColMajor} \) and \( \text{uplo} = \text{Nag\_Upper} \),
   \( A_{ij} \) is stored in \( \text{ap}[i \times (j-1)/2 + j - 1] \), for \( i \leq j \);
   if \( \text{order} = \text{Nag\_ColMajor} \) and \( \text{uplo} = \text{Nag\_Lower} \),
   \( A_{ij} \) is stored in \( \text{ap}[i \times (j-1)/2 + i - 1] \), for \( i \geq j \);
   if \( \text{order} = \text{Nag\_RowMajor} \) and \( \text{uplo} = \text{Nag\_Upper} \),
   \( A_{ij} \) is stored in \( \text{ap}[i \times (j-1)/2 + j - 1] \), for \( i \leq j \);
   if \( \text{order} = \text{Nag\_RowMajor} \) and \( \text{uplo} = \text{Nag\_Lower} \),
   \( A_{ij} \) is stored in \( \text{ap}[i \times (j-1)/2 + j - 1] \), for \( i \geq j \).

   If \( \text{diag} = \text{Nag\_UnitDiag} \), the diagonal elements of \( \text{AP} \) are assumed to be 1, and are not referenced;
   the same storage scheme is used whether \( \text{diag} = \text{Nag\_NonUnitDiag} \) or \( \text{diag} = \text{Nag\_UnitDiag} \).

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

6: \( \text{fail} \) – NagError *
   \( \text{Input/Output} \)
   The NAG error argument (see Section 3.6 in the Essential Introduction).

6 \ Error Indicators and Warnings

\textbf{NE\_ALLOC\_FAIL}
   Dynamic memory allocation failed.
   See Section 3.2.1.2 in the Essential Introduction for further information.

\textbf{NE\_BAD\_PARAM}
   On entry, argument \( \langle \text{value} \rangle \) had an illegal value.

\textbf{NE\_INT}
   On entry, \( n = \langle \text{value} \rangle \).
   Constraint: \( n \geq 0. \)

\textbf{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.

\textbf{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.

\textbf{NE\_SINGULAR}
   Element \( \langle \text{value} \rangle \) of the diagonal is exactly zero. \( A \) is singular its inverse cannot be computed.
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 $\epsilon$ 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

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


8 Parallelism and Performance

nag_ztptri (f07uwc) is not threaded by NAG in any implementation.

nag_ztptri (f07uwc) 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 $\frac{4}{3}n^3$.

The real analogue of this function is nag_dtptri (f07udc).

10 Example

This example computes the inverse of the matrix $A$, where

$$A = \begin{pmatrix}
4.78 + 4.56i & 0.00 + 0.00i & 0.00 + 0.00i & 0.00 + 0.00i \\
2.00 - 0.30i & -4.11 + 1.25i & 0.00 + 0.00i & 0.00 + 0.00i \\
2.89 - 1.34i & 2.36 - 4.25i & 4.15 + 0.80i & 0.00 + 0.00i \\
-1.89 + 1.15i & 0.04 - 3.69i & -0.02 + 0.46i & 0.33 - 0.26i
\end{pmatrix},$$

using packed storage.

10.1 Program Text

/* nag_ztptri (f07uwc) 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;
    Nag_UploType uplo;
NagError fail;
Nag_OrderType order;
/* Arrays */
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_ztptri (f07uwc) 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 (!(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
        }
    }
```c
#ifdef _WIN32
    scanf_s("%*[\n"");
#else
    scanf("%*[\n"");
#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);
            #endif
        }
        #ifdef _WIN32
            scanf_s("%*[\n"");
        #else
            scanf("%*[\n"");
        #endif
    }
    /* Compute inverse of A */
    /* nag_ztptri (f07uwc). *
       * Inverse of complex triangular matrix, packed storage *
    */
    nag_ztptri(order, uplo, Nag_NonUnitDiag, n, ap, &fail);
    if (fail.code != NE_NOERROR)
    {
        printf("Error from nag_ztptri (f07uwc).\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(ap);
return exit_status;
}

10.2 Program Data

nag_ztptri (f07uwc) Example Program Data

4 :Value of n
Nag_Lower :Value of uplo
( 4.78, 4.56)
( 2.00,-0.30) (-4.11, 1.25)
( 2.89,-1.34) ( 2.36,-4.25) ( 4.15, 0.80)
(-1.89, 1.15) ( 0.04,-3.69) (-0.02, 0.46) ( 0.33,-0.26) :End of matrix A
```
## 10.3 Program Results

nag_ztptri (f07uwc) Example Program Results

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( 0.1095, -0.1045)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>( 0.0582, -0.0411)</td>
<td>( -0.2227, -0.0677)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>( 0.0032,  0.1905)</td>
<td>( 0.1538, -0.2192)</td>
<td>( 0.2323, -0.0448)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>( 0.7602,  0.2814)</td>
<td>( 1.6184, -1.4346)</td>
<td>( 0.1289, -0.2250)</td>
<td>( 1.8697,  1.4731)</td>
</tr>
</tbody>
</table>