

**nag\_complex\_lu (f03ahc)****1. Purpose**

**nag\_complex\_lu (f03ahc)** computes an  $LU$  factorization of a complex matrix, with partial pivoting, and evaluates the determinant.

**2. Specification**

```
#include <nag.h>
#include <nagf03.h>
```

```
void nag_complex_lu(Integer n, Complex a[], Integer tda, Integer pivot[],
    Complex *det, Integer *dete, NagError *fail)
```

**3. Description**

This function computes an  $LU$  factorization of a complex matrix  $A$ , with partial pivoting:  $PA = LU$ , where  $P$  is a permutation matrix,  $L$  is lower triangular and  $U$  is unit upper triangular. The determinant is the product of the diagonal elements of  $L$  with the correct sign determined by the row interchanges.

**4. Parameters****n**

Input:  $n$ , the order of the matrix  $A$ .  
Constraint:  $n \geq 1$ .

**a[n][tda]**

Input: the  $n$  by  $n$  matrix  $A$ .  
Output:  $A$  is overwritten by the lower triangular matrix  $L$  and the off-diagonal elements of the upper triangular matrix  $U$ . The unit diagonal elements of  $U$  are not stored.

**tda**

Input: the second dimension of the array **a** as declared in the function from which **nag\_complex\_lu** is called.  
Constraint: **tda**  $\geq$  **n**.

**pivot[n]**

Output: **pivot**[ $i - 1$ ] gives the row index of the  $i$ th pivot.

**det****dete**

Output: the determinant of  $A$  is given by  $(\mathbf{det.re} + i\mathbf{det.im}) \times 2.0^{\mathbf{dete}}$ . It is given in this form to avoid overflow and underflow.

**fail**

The NAG error parameter, see the Essential Introduction to the NAG C Library.

**5. Error Indications and Warnings****NE\_SINGULAR**

The matrix  $A$  is singular, possibly due to rounding errors. The factorization could not be completed. **detf** and **dete** are set to zero.

**NE\_INT\_ARG\_LT**

On entry, **n** must not be less than 1: **n** =  $\langle value \rangle$ .

**NE\_2\_INT\_ARG\_LT**

On entry, **tda** =  $\langle value \rangle$  while **n** =  $\langle value \rangle$ . The parameters must satisfy **tda**  $\geq$  **n**.

**NE\_ALLOC\_FAIL**

Memory allocation failed.

## 6. Further Comments

The time taken by the function is approximately proportional to  $n^3$ .

### 6.1. Accuracy

The accuracy of the determinant depends on the conditioning of the original matrix. For a detailed error analysis see Wilkinson and Reinsch (1971) p 107.

### 6.2. References

Wilkinson J H and Reinsch C (1971) *Handbook for Automatic Computation (Vol II, Linear Algebra)* Springer-Verlag pp 93–110.

## 7. See Also

nag\_complex\_lin\_eqn\_mult\_rhs (f04adc)  
nag\_complex\_lu\_solve\_mult\_rhs (f04akc)

## 8. Example

To compute an *LU* factorization, with partial pivoting, and calculate the determinant, of the complex matrix

$$\begin{pmatrix} 2 & 1 + 2i & 2 + 10i \\ 1 + i & 1 + 3i & -5 + 14i \\ 1 + i & 5i & -7 + 20i \end{pmatrix}.$$

### 8.1. Program Text

```
/* nag_complex_lu(f03ahc) Example Program
 *
 * Copyright 1990 Numerical Algorithms Group.
 *
 * Mark 1A revised, (Oct 1990).
 */

#include <nag.h>
#include <math.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagf03.h>

main()
{
#define NMAX 5
#define TDA NMAX

    Integer pivot[NMAX];
    Complex a[NMAX][TDA], det;
    Integer i, j, n, dete;
    static NagError fail;

    Vprintf("f03ahc Example Program Results\n");
    Vscanf("%*[\n]"); /* Skip heading in data file */
    fail.print = TRUE;

    if (scanf("%ld",&n)!=EOF)
        if (n > 0 && n <= NMAX)
            {
                for (i = 0; i < n; i++)
                    for (j = 0; j < n; j++)
                        Vscanf(" ( %lf , %lf ) ", &a[i][j].re, &a[i][j].im);
                f03ahc(n, (Complex *)a, (Integer)TDA, pivot, &det, &dete, &fail);
                if (fail.code!=NE_NOERROR)
                    exit(EXIT_FAILURE);
                else
                    {

```

```

Vprintf("Array a after factorization\n");
for (i=0; i<n; i++)
{
    for (j=0; j<n; j++)
        Vprintf("(%7.3f, %7.3f) ", a[i][j].re, a[i][j].im);
    Vprintf("\n");
}
Vprintf("\nArray pivot\n");
for (i=0; i<n; i++)
    Vprintf("%5ld",pivot[i]);
Vprintf("\n\ndet.re = %7.4f, det.im = %7.4f, dete = %2ld.\n",
        det.re, det.im, dete);
det.re = ldexp(det.re, (int)dete);
det.im = ldexp(det.im, (int)dete);
Vprintf("\nValue of determinant = (%7.4f, %7.4f)\n", det.re, det.im)
}
}
else
{
    Vfprintf(stderr, "Error: n is out of range: n = %5ld\n", n);
    exit(EXIT_FAILURE);
}
exit(EXIT_SUCCESS);
}

```

## 8.2. Program Data

```

f03ahc Example Program Data
3
(2.0, 0.0) (1.0, 2.0) (2.0,10.0)
(1.0, 1.0) (1.0, 3.0) (-5.0,14.0)
(1.0, 1.0) (0.0, 5.0) (-7.0,20.0)

```

## 8.3. Program Results

```

f03ahc Example Program Results
Array a after factorization
( 2.000,  0.000) ( 0.500,  1.000) ( 1.000,  5.000)
( 1.000,  1.000) ( 0.500,  3.500) ( 3.800,  1.400)
( 1.000,  1.000) ( 1.500,  1.500) (-4.600,  0.200)

Array pivot
 1  3  3

det.re =  0.0234, det.im =  0.1250, dete =  8.

Value of determinant = ( 6.0000, 32.0000)

```

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