NAG Library Function Document

nag_zherk (f16zpc)

1 Purpose

nag_zherk (f16zpc) performs a rank-k update on a complex Hermitian matrix.

2 Specification

```
#include <nag.h>
#include <nagf16.h>
```

```
void nag_zherk (Nag_OrderType order, Nag_UploType uplo, Nag_TransType trans,
     Integer n, Integer k, double alpha, const Complex a[], Integer pda,
     double beta, Complex c[], Integer pdc, NagError *fail)
```

3 Description

nag_zherk (f16zpc) performs one of the Hermitian rank-k update operations

$$C \leftarrow \alpha AA^{\mathrm{H}} + \beta C \quad \text{or} \quad C \leftarrow \alpha A^{\mathrm{H}}A + \beta C,$$

where A is a complex matrix, C is an n by n complex Hermitian matrix, and α and β are real scalars.

4 References

Basic Linear Algebra Subprograms Technical (BLAST) Forum (2001) *Basic Linear Algebra Subprograms Technical (BLAST) Forum Standard* University of Tennessee, Knoxville, Tennessee http://www.netlib.org/blas/blast-forum/blas-report.pdf

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 the upper or lower triangular part of C is stored.

uplo = Nag_Upper
The upper triangular part of C is stored.

uplo = Nag_Lower
The lower triangular part of C is stored.

Constraint: **uplo** = Nag_Upper or Nag_Lower.

3: **trans** – Nag_TransType *Input*

On entry: specifies the operation to be performed.

trans = Nag_NoTrans
$C \leftarrow \alpha AA^{\mathrm{H}} + \beta C$.

trans $=$ Nag_ConjTrans
$C \leftarrow \alpha A^{\mathrm{H}} A + \beta C.$

Constraint: **trans** $=$ Nag_NoTrans or Nag_ConjTrans.

4: **n** – Integer *Input*

On entry: n, the order of the matrix C; the number of rows of A if **trans** $=$ Nag_NoTrans, or the number of columns of A otherwise.

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

5: **k** – Integer *Input*

On entry: k, the number of columns of A if **trans** $=$ Nag_NoTrans, or the number of rows of A otherwise.

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

6: **alpha** – double *Input*

On entry: the scalar α.

7: **a**[*dim*] – const Complex *Input*

Note: the dimension, *dim*, of the array **a** must be at least

$\max(1, \mathbf{pda} \times \mathbf{k})$ when **trans** $=$ Nag_NoTrans and **order** $=$ Nag_ColMajor;
$\max(1, \mathbf{n} \times \mathbf{pda})$ when **trans** $=$ Nag_NoTrans and **order** $=$ Nag_RowMajor;
$\max(1, \mathbf{pda} \times \mathbf{n})$ when **trans** $=$ Nag_Trans or Nag_ConjTrans and **order** $=$ Nag_ColMajor;
$\max(1, \mathbf{k} \times \mathbf{pda})$ when **trans** $=$ Nag_Trans or Nag_ConjTrans and **order** $=$ Nag_RowMajor.

If **order** $=$ 'Nag_ColMajor', A_{ij} is stored in $\mathbf{a}[(j-1) \times \mathbf{pda} + i - 1]$.

If **order** $=$ 'Nag_RowMajor', A_{ij} is stored in $\mathbf{a}[(i-1) \times \mathbf{pda} + j - 1]$.

On entry: the matrix A; A is n by k if **trans** $=$ Nag_NoTrans, or k by n otherwise.

8: **pda** – Integer *Input*

On entry: the stride separating row or column elements (depending on the value of **order**) in the array **a**.

Constraints:

if **order** $=$ Nag_ColMajor,

if **trans** $=$ Nag_NoTrans, $\mathbf{pda} \geq \max(1, \mathbf{n})$;
if **trans** $=$ Nag_Trans or Nag_ConjTrans, $\mathbf{pda} \geq \max(1, \mathbf{k})$.;

if **order** $=$ Nag_RowMajor,

if **trans** $=$ Nag_NoTrans, $\mathbf{pda} \geq \max(1, \mathbf{k})$;
if **trans** $=$ Nag_Trans or Nag_ConjTrans, $\mathbf{pda} \geq \max(1, \mathbf{n})$..

9: **beta** – double *Input*

On entry: the scalar β.

10: **c**[*dim*] – Complex *Input/Output*

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

On entry: the n by n Hermitian matrix C.

If **order** $=$ 'Nag_ColMajor', C_{ij} is stored in $\mathbf{c}[(j-1) \times \mathbf{pdc} + i - 1]$.

If **order** $=$ 'Nag_RowMajor', C_{ij} is stored in $\mathbf{c}[(i-1) \times \mathbf{pdc} + j - 1]$.

If **uplo** = 'Nag_Upper', the upper triangular part of C must be stored and the elements of the array below the diagonal are not referenced.

If **uplo** = 'Nag_Lower', the lower triangular part of C must be stored and the elements of the array above the diagonal are not referenced.

On exit: the updated matrix C. The imaginary parts of the diagonal elements are set to zero.

11: **pdc** – Integer *Input*

On entry: the stride separating row or column elements (depending on the value of **order**) of the matrix C in the array **c**.

Constraint: $\mathbf{pdc} \geq \max(1, \mathbf{n})$.

12: **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.

NE_BAD_PARAM

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

NE_ENUM_INT_2

On entry, **trans** = $\langle value \rangle$, **k** = $\langle value \rangle$, **pda** = $\langle value \rangle$.
Constraint: if **trans** = Nag_NoTrans, $\mathbf{pda} \geq \max(1, \mathbf{k})$.

On entry, **trans** = $\langle value \rangle$, **k** = $\langle value \rangle$, **pda** = $\langle value \rangle$.
Constraint: if **trans** = Nag_Trans or Nag_ConjTrans, $\mathbf{pda} \geq \max(1, \mathbf{k})$.

On entry, **trans** = $\langle value \rangle$, **n** = $\langle value \rangle$, **pda** = $\langle value \rangle$.
Constraint: if **trans** = Nag_NoTrans, $\mathbf{pda} \geq \max(1, \mathbf{n})$.

On entry, **trans** = $\langle value \rangle$, **n** = $\langle value \rangle$, **pda** = $\langle value \rangle$.
Constraint: if **trans** = Nag_Trans or Nag_ConjTrans, $\mathbf{pda} \geq \max(1, \mathbf{n})$.

NE_INT

On entry, **k** = $\langle value \rangle$.
Constraint: $\mathbf{k} \geq 0$.

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

NE_INT_2

On entry, **pdc** = $\langle value \rangle$, **n** = $\langle value \rangle$.
Constraint: $\mathbf{pdc} \geq \max(1, \mathbf{n})$.

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.

7 Accuracy

The BLAS standard requires accurate implementations which avoid unnecessary over/underflow (see Section 2.7 of Basic Linear Algebra Subprograms Technical (BLAST) Forum (2001)).

8 Parallelism and Performance

Not applicable.

9 Further Comments

None.

10 Example

Perform rank-k update of complex Hermitian 4 by 4 matrix C using 4 by 2 matrix A ($k = 2$), $C = C - AA^{\mathrm{T}}$, where

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

and

$$A = \begin{pmatrix} 1.7 + -2.3i & -1.8 + 2.4i \\ 2.9 + -2.1i & 1.2 + 1.4i \\ -2.9 + 1.0i & 0.6 + 0.8i \\ 1.5 + 0.9i & -1.4 + -1.7i \end{pmatrix}.$$

10.1 Program Text

```
/* nag_zherk (f16zpc) Example Program.
 *
 * Copyright 2005 Numerical Algorithms Group.
 *
 * Mark 8, 2005.
 */

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagf16.h>
#include <nagx04.h>

int main(void)
{

  /* Scalars */
  double         alpha, beta;
  Integer        adim1, adim2, exit_status, i, j, k, n, pda, pdc;

  /* Arrays */
  Complex        *a = 0, *c = 0;
  char           nag_enum_arg[40];

  /* Nag Types */
  NagError       fail;
  Nag_OrderType  order;
  Nag_UploType   uplo;
  Nag_TransType  trans;
  Nag_MatrixType matrix;

#ifdef NAG_COLUMN_MAJOR
#define A(I, J) a[(J-1)*pda + I - 1]
#define C(I, J) c[(J-1)*pdc + I - 1]
  order = Nag_ColMajor;
#else
#define A(I, J) a[(I-1)*pda + J - 1]
#define C(I, J) c[(I-1)*pdc + J - 1]
  order = Nag_RowMajor;
```

```
#endif

  exit_status = 0;
  INIT_FAIL(fail);

  printf("nag_zherk (f16zpc) Example Program Results\n\n");

  /* Skip heading in data file */
  scanf("%*[^\n] ");

  /* Read the problem dimensions */
  scanf("%ld%ld%*[^\n] ", &n, &k);

  /* Read the uplo parameter */
  scanf("%39s%*[^\n] ", nag_enum_arg);
  /* nag_enum_name_to_value (x04nac).
   * Converts NAG enum member name to value
   */
  uplo = (Nag_UploType) nag_enum_name_to_value(nag_enum_arg);
  /* Read the transpose parameter */
  scanf("%39s%*[^\n] ", nag_enum_arg);
  /* nag_enum_name_to_value (x04nac), see above. */
  trans = (Nag_TransType) nag_enum_name_to_value(nag_enum_arg);
  /* Read scalar parameters */
  scanf("%lf%lf%*[^\n] ", &alpha, &beta);

  if (trans == Nag_NoTrans)
    {
      adim1 = n;
      adim2 = k;
    }
  else
    {
      adim1 = k;
      adim2 = n;
    }

#ifdef NAG_COLUMN_MAJOR
  pda = adim1;
#else
  pda = adim2;
#endif
  pdc = n;
  if (k > 0 && n > 0)
    {
      /* Allocate memory */
      if (!(a = NAG_ALLOC(k*n, Complex)) ||
          !(c = NAG_ALLOC(n*n, Complex)))
        {
          printf("Allocation failure\n");
          exit_status = -1;
          goto END;
        }
    }
  else
    {
      printf("Invalid k or n\n");
      exit_status = 1;
      return exit_status;
    }

  /* Input matrix A. */
  for (i = 1; i <= adim1; ++i)
    {
      for (j = 1; j <= adim2; ++j)
        scanf(" ( %lf , %lf )", &A(i, j).re, &A(i, j).im);
      scanf("%*[^\n] ");
    }
  /* Input matrix C. */
  if (uplo == Nag_Upper)
    {
```

```
      for (i = 1; i <= n; ++i)
        {
          for (j = i; j <= n; ++j)
            scanf(" ( %lf , %lf )", &C(i, j).re, &C(i, j).im);
        }
      scanf("%*[^\n] ");
    }
  else
    {
      for (i = 1; i <= n; ++i)
        {
          for (j = 1; j <= i; ++j)
            scanf(" ( %lf , %lf )", &C(i, j).re, &C(i, j).im);
        }
      scanf("%*[^\n] ");
    }

  /* nag_zherk (f16zpc).
   * Rank k update of complex Hermitian matrix.
   *
   */
  nag_zherk(order, uplo, trans, n, k, alpha, a, pda, beta, c, pdc,
            &fail);
  if (fail.code != NE_NOERROR)
    {
      printf("Error from nag_zherk (f16zpc).\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }
  if (uplo == Nag_Upper)
    {
      matrix = Nag_UpperMatrix;
    }
  else
    {
      matrix = Nag_LowerMatrix;
    }
  /* Print updated matrix C */
  /* nag_gen_complx_mat_print_comp (x04dbc).
   * Print complex general matrix (comprehensive)
   */
  fflush(stdout);
  nag_gen_complx_mat_print_comp(order, matrix, Nag_NonUnitDiag, n, n, c,
                                pdc, Nag_BracketForm, "%6.2f",
                                "Updated Matrix C", Nag_IntegerLabels,
                                0, Nag_IntegerLabels, 0, 80, 0, 0,
                                &fail);
  if (fail.code != NE_NOERROR)
    {
      printf("Error from nag_gen_complx_mat_print_comp (x04dbc).\n%s"
              "\n", fail.message);
      exit_status = 1;
      goto END;
    }
 END:
  NAG_FREE(a);
  NAG_FREE(c);

  return exit_status;
}
```

10.2 Program Data

```
nag_zherk (f16zpc) Example Program Data
  4  2                        :Values of n and k
  Nag_Lower                   :Value of uplo
  Nag_NoTrans                 :Value of trans
 -1.0  1.0                    :Values of alpha and beta
 (  1.7, -2.3) ( -1.8,  2.4)
 (  2.9, -2.1) (  1.2,  1.4)
```

```
( -2.9,  1.0) (  0.6,  0.8)
(  1.5,  0.9) ( -1.4, -1.7)                                  :End of matrix A
( 4.78, 0.00)
( 2.00,-0.30) (-4.11, 0.00)
( 2.89,-1.34) ( 2.36,-4.25) ( 4.15, 0.00)
(-1.89, 1.15) ( 0.04,-3.69) (-0.02, 0.46) ( 0.33, 0.00) :End of matrix C
```

10.3 Program Results

```
nag_zherk (f16zpc) Example Program Results

 Updated Matrix C
                  1                 2                 3                 4
 1  (-12.40,  0.00)
 2  ( -8.96,  2.00)  (-20.33,  0.00)
 3  (  9.28,  6.51)  ( 11.03, -1.18)  ( -6.26,  0.00)
 4  ( -0.81,-10.25)  (  1.64, -9.37)  (  5.63,  4.47)  ( -7.58,  0.00)
```