NAG Library Function Document

nag_ztrmv (f16sfc)

1 Purpose

nag_ztrmv (f16sfc) performs matrix-vector multiplication for a complex triangular matrix.

2 Specification

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

```
void nag_ztrmv (Nag_OrderType order, Nag_UploType uplo, Nag_TransType trans,
     Nag_DiagType diag, Integer n, Complex alpha, const Complex a[],
     Integer pda, Complex x[], Integer incx, NagError *fail)
```

3 Description

nag_ztrmv (f16sfc) performs one of the matrix-vector operations

$$x \leftarrow \alpha Ax, \quad x \leftarrow \alpha A^{\mathrm{T}}x \quad \text{or} \quad x \leftarrow \alpha A^{\mathrm{H}}x,$$

where A is an n by n complex triangular matrix, and x is an n-element complex vector and α is a complex scalar.

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 2.3.1.3 in How to Use the NAG Library and its Documentation 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: **trans** – Nag_TransType *Input*

On entry: specifies the operation to be performed.

trans = Nag_NoTrans
$x \leftarrow \alpha Ax$.

trans = Nag_Trans
$x \leftarrow \alpha A^T x$.

trans = Nag_ConjTrans
$x \leftarrow \alpha A^H x$.

Constraint: **trans** = Nag_NoTrans, Nag_Trans or Nag_ConjTrans.

4: **diag** – Nag_DiagType *Input*

On entry: specifies whether A has nonunit or unit diagonal elements.

diag = Nag_NonUnitDiag
The diagonal elements are stored explicitly.

diag = Nag_UnitDiag
The diagonal elements are assumed to be 1 and are not referenced.

Constraint: **diag** = Nag_NonUnitDiag or Nag_UnitDiag.

5: **n** – Integer *Input*

On entry: n, the order of the matrix A.

Constraint: **n** ≥ 0.

6: **alpha** – Complex *Input*

On entry: the scalar α.

7: **a**[dim] – const Complex *Input*

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

On entry: the n by n triangular matrix A.

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 $\mathbf{a}[(i-1) \times \mathbf{pda} + j - 1]$.

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

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

If **diag** = Nag_UnitDiag, the diagonal elements of A are assumed to be 1, and are not referenced.

8: **pda** – Integer *Input*

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

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

9: **x**[dim] – Complex *Input/Output*

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

On entry: the right-hand side vector b.

On exit: the solution vector x.

10: **incx** – Integer *Input*

On entry: the increment in the subscripts of **x** between successive elements of x.

Constraint: **incx** $\neq 0$.

11: **fail** – NagError * *Input/Output*

The NAG error argument (see Section 2.7 in How to Use the NAG Library and its Documentation).

6 Error Indicators and Warnings

NE_ALLOC_FAIL

Dynamic memory allocation failed.
See Section 2.3.1.2 in How to Use the NAG Library and its Documentation for further information.

NE_BAD_PARAM

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

NE_INT

On entry, **incx** $= \langle value \rangle$.
Constraint: **incx** $\neq 0$.

On entry, **n** $= \langle value \rangle$.
Constraint: **n** ≥ 0.

NE_INT_2

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

NE_INTERNAL_ERROR

An unexpected error has been triggered by this function. Please contact NAG.
See Section 2.7.6 in How to Use the NAG Library and its Documentation for further information.

NE_NO_LICENCE

Your licence key may have expired or may not have been installed correctly.
See Section 2.7.5 in How to Use the NAG Library and its Documentation for further information.

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

nag_ztrmv (f16sfc) is not threaded in any implementation.

9 Further Comments

None.

10 Example

This example computes the matrix-vector product

$$y = \alpha A x$$

where

$$A = \begin{pmatrix} 1.0 + 1.0i & 0.0 + 0.0i & 0.0 + 0.0i & 0.0 + 0.0i \\ 2.0 + 1.0i & 2.0 + 2.0i & 0.0 + 0.0i & 0.0 + 0.0i \\ 3.0 + 1.0i & 3.0 + 2.0i & 3.0 + 3.0i & 0.0 + 0.0i \\ 4.0 + 1.0i & 4.0 + 2.0i & 4.0 + 3.0i & 4.0 + 4.0i \end{pmatrix},$$

$$x = \begin{pmatrix} -1.0 + 1.0i \\ 2.0 - 2.0i \\ -3.0 + 2.0i \\ -2.0 + 1.0i \end{pmatrix}$$

and

$$\alpha = 1.0 + 0.0i.$$

10.1 Program Text

```
/* nag_ztrmv (f16sfc) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */

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

int main(void)
{

  /* Scalars */
  Complex alpha;
  Integer exit_status, i, incx, j, n, pda, xlen;

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

  /* Nag Types */
  NagError fail;
  Nag_DiagType diag;
  Nag_OrderType order;
  Nag_TransType trans;
  Nag_UploType uplo;

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

  exit_status = 0;
  INIT_FAIL(fail);

  printf("nag_ztrmv (f16sfc) Example Program Results\n\n");

  /* Skip heading in data file */
#ifdef _WIN32
  scanf_s("%*[^\n] ");
#else
  scanf("%*[^\n] ");
#endif
```

```
  /* Read the problem dimension */
#ifdef _WIN32
  scanf_s("%" NAG_IFMT "%*[^\n] ", &n);
#else
  scanf("%" NAG_IFMT "%*[^\n] ", &n);
#endif
  /* Read uplo */
#ifdef _WIN32
  scanf_s("%39s%*[^\n] ", nag_enum_arg, (unsigned)_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);
  /* Read trans */
#ifdef _WIN32
  scanf_s("%39s%*[^\n] ", nag_enum_arg, (unsigned)_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
   */
  trans = (Nag_TransType) nag_enum_name_to_value(nag_enum_arg);
  /* Read diag */
#ifdef _WIN32
  scanf_s("%39s%*[^\n] ", nag_enum_arg, (unsigned)_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
   */
  diag = (Nag_DiagType) nag_enum_name_to_value(nag_enum_arg);
  /* Read scalar parameters */
#ifdef _WIN32
  scanf_s(" ( %lf , %lf )%*[^\n] ", &alpha.re, &alpha.im);
#else
  scanf(" ( %lf , %lf )%*[^\n] ", &alpha.re, &alpha.im);
#endif
  /* Read increment parameters */
#ifdef _WIN32
  scanf_s("%" NAG_IFMT "%*[^\n] ", &incx);
#else
  scanf("%" NAG_IFMT "%*[^\n] ", &incx);
#endif

  pda = n;
  xlen = MAX(1, 1 + (n - 1) * ABS(incx));

  if (n > 0) {
    /* Allocate memory */
    if (!(a = NAG_ALLOC(n * pda, Complex)) || !(x = NAG_ALLOC(xlen, Complex)))
    {
      printf("Allocation failure\n");
      exit_status = -1;
      goto END;
    }
  }
  else {
    printf("Invalid n\n");
    exit_status = 1;
    return exit_status;
  }

  /* Read A from data file */
  if (uplo == Nag_Upper) {
    for (i = 1; i <= n; ++i) {
      for (j = i; j <= n; ++j)
```

```
#ifdef _WIN32
        scanf_s(" ( %lf , %lf )", &A(i, j).re, &A(i, j).im);
#else
        scanf(" ( %lf , %lf )", &A(i, j).re, &A(i, j).im);
#endif
    }
#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(i, j).re, &A(i, j).im);
#else
        scanf(" ( %lf , %lf )", &A(i, j).re, &A(i, j).im);
#endif
    }
#ifdef _WIN32
    scanf_s("%*[^\n] ");
#else
    scanf("%*[^\n] ");
#endif
  }

  /* Input vector x */
  for (i = 1; i <= xlen; ++i)
#ifdef _WIN32
    scanf_s(" ( %lf , %lf )%*[^\n] ", &x[i - 1].re, &x[i - 1].im);
#else
    scanf(" ( %lf , %lf )%*[^\n] ", &x[i - 1].re, &x[i - 1].im);
#endif

  /* nag_ztrmv (f16sfc).
   * Complex triangular matrix-vector multiply.
   *
   */
  nag_ztrmv(order, uplo, trans, diag, n, alpha, a, pda, x, incx, &fail);
  if (fail.code != NE_NOERROR) {
    printf("Error from nag_ztrmv (f16sfc).\n%s\n", fail.message);
    exit_status = 1;
    goto END;
  }

  /* Print output vector x */
  printf("%s\n", "  x");
  for (i = 1; i <= xlen; ++i)
    printf("(%11f,%11f)\n", x[i - 1].re, x[i - 1].im);

END:
  NAG_FREE(a);
  NAG_FREE(x);

  return exit_status;
}
```

10.2 Program Data

```
nag_ztrmv (f16sfc) Example Program Data
  4                            :Value of n
  Nag_Lower                    :Value of uplo
  Nag_NoTrans                  :Value of trans
  Nag_NonUnitDiag              :Value of diag
  ( 1.0, 0.0)                  :Value of alpha
  1                            :Value of incx
  ( 1.0, 1.0)
  ( 2.0, 1.0)   ( 2.0, 2.0)
```

```
  ( 3.0, 1.0)   ( 3.0, 2.0)   ( 3.0, 3.0)
  ( 4.0, 1.0)   ( 4.0, 2.0)   ( 4.0, 3.0)   ( 4.0, 4.0) :End of matrix A
  (-1.0, 1.0)
  ( 2.0,-2.0)
  (-3.0, 2.0)
  (-2.0, 1.0)                          :End of vector x
```

10.3 Program Results

```
nag_ztrmv (f16sfc) Example Program Results

  x
(  -2.000000,   0.000000)
(   5.000000,   1.000000)
(  -9.000000,  -3.000000)
( -23.000000,  -6.000000)
```