NAG Library Function Document

nag_dspmv (f16pec)

1 Purpose

nag_dspmv (f16pec) performs matrix-vector multiplication for a real symmetric matrix stored in packed form.

2 Specification

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

void nag_dspmv (Nag_OrderType order, Nag_UploType uplo, Integer n,
     double alpha, const double ap[], const double x[], Integer incx,
     double beta, double y[], Integer incy, NagError *fail)
```

3 Description

nag_dspmv (f16pec) performs the matrix-vector operation

$$y \leftarrow \alpha A x + \beta y,$$

where A is an n by n real symmetric matrix stored in packed form, x and y are n-element real vectors, 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 A is stored.

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

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

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

3: **n** – Integer *Input*

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

Constraint: **n** ≥ 0.

4: **alpha** – double *Input*

On entry: the scalar α.

5: **ap**[dim] – const double *Input*

Note: the dimension, *dim*, of the array **ap** must be at least $\max(1, \mathbf{n} \times (\mathbf{n}+1)/2)$.

On entry: the n by n symmetric matrix A, packed by rows or columns.

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

6: **x**[dim] – const double *Input*

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

On entry: the vector x.

7: **incx** – Integer *Input*

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

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

8: **beta** – double *Input*

On entry: the scalar β.

9: **y**[dim] – double *Input/Output*

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

On entry: the vector y.

If **beta** $= 0$, **y** need not be set.

On exit: the updated vector y.

10: **incy** – Integer *Input*

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

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

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

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

6 Error Indicators and Warnings

NE_BAD_PARAM

On entry, argument ⟨*value*⟩ had an illegal value.

NE_INT

On entry, **incx** = ⟨*value*⟩.
Constraint: **incx** $\neq 0$.

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

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

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

This example computes the matrix-vector product

$$y = \alpha A x + \beta y$$

where

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

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

$$y = \begin{pmatrix} 4.0 \\ 7.5 \\ 8.0 \\ 13.0 \end{pmatrix},$$

$$\alpha = 1.5 \quad \text{and} \quad \beta = 1.0.$$

10.1 Program Text

```
/* nag_dspmv (f16pec) Example Program.
 *
 * Copyright 2005 Numerical Algorithms Group.
 *
 * Mark 8, 2005.
 */

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

int main(void)
{

  /* Scalars */
```

```
  double        alpha, beta;
  Integer       aplen, exit_status, i, incx, incy, j, n, xlen, ylen;

  /* Arrays */
  double        *ap = 0, *x = 0, *y = 0;
  char          nag_enum_arg[40];

  /* Nag Types */
  NagError      fail;
  Nag_OrderType order;
  Nag_UploType  uplo;

#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

  exit_status = 0;
  INIT_FAIL(fail);

  printf("nag_dspmv (f16pec) Example Program Results\n\n");

  /* Skip heading in data file */
  scanf("%*[^\n] ");
  /* Read the problem dimension */
  scanf("%ld%*[^\n] ", &n);
  /* Read uplo */
  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 scalar parameters */
  scanf("%lf%lf%*[^\n] ", &alpha, &beta);
  /* Read increment parameters */
  scanf("%ld%ld%*[^\n] ", &incx, &incy);

  aplen = n*(n+1)/2;
  xlen = MAX(1, 1 + (n - 1)*ABS(incx));
  ylen = MAX(1, 1 + (n - 1)*ABS(incy));


  if (n > 0)
    {
      /* Allocate memory */
      if (!(ap = NAG_ALLOC(aplen, double)) ||
          !(x = NAG_ALLOC(xlen, double)) ||
          !(y = NAG_ALLOC(ylen, double)))
        {
          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)
            scanf("%lf", &A_UPPER(i, j));
        }
      scanf("%*[^\n] ");
    }
  else
    {
      for (i = 1; i <= n; ++i)
        {
          for (j = 1; j <= i; ++j)
            scanf("%lf", &A_LOWER(i, j));
        }
      scanf("%*[^\n] ");
    }

  /* Input vectors x and y */
  for (i = 1; i <= xlen; ++i)
    scanf("%lf%*[^\n] ", &x[i - 1]);
  for (i = 1; i <= ylen; ++i)
    scanf("%lf%*[^\n] ", &y[i - 1]);

  /* nag_dspmv (f16pec).
   * Symmetric packed storage matrix-vector multiply.
   *
   */
  nag_dspmv(order, uplo, n, alpha, ap, x, incx, beta, y,
            incy, &fail);
  if (fail.code != NE_NOERROR)
    {
      printf("Error from nag_dspmv.\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }

  /* Print output vector y */
  printf("%s\n", "  y");
  for (i = 1; i <= ylen; ++i)
    {
      printf("%11f\n", y[i-1]);
    }

 END:
  NAG_FREE(ap);
  NAG_FREE(x);
  NAG_FREE(y);

  return exit_status;
}
```

10.2 Program Data

```
nag_dspmv (f16pec) Example Program Data
  4                         :Value of n
  Nag_Lower                 :Value of uplo
  1.5 1.0                   :Values of alpha, beta
  1 1                       :Values of incx, incy
  1.0
  2.0   2.0
  3.0   3.0   3.0
  4.0   4.0   4.0   4.0     :End of matrix A
   -1.0
    2.0
   -3.0
    1.0                     :End of vector x
    4.0
    7.5
    8.0
   13.0                     :End of vector y
```

10.3 Program Results

```
nag_dspmv (f16pec) Example Program Results

  y
   1.000000
   3.000000
   5.000000
   7.000000
```