NAG C Library Function Document

nag_dspr2 (f16psc)

1 Purpose

nag_dspr2 (f16psc) performs a rank-2 update on a real symmetric matrix stored in packed form.

2 Specification

```
#include <nag.h>
#include <nagf16.h>
void nag_dspr2 (Nag_OrderType order, Nag_UploType uplo, Integer n, double alpha,
     const double x[], Integer incx, const double y[], Integer incy, double beta,
     double ap[], NagError *fail)
```

3 Description

nag_dspr2 (f16psc) performs the symmetric rank-2 update operation

$$A \leftarrow \alpha x y^{\mathrm{T}} + \alpha y x^{\mathrm{T}} + \beta A,$$

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

4 References

The BLAS Technical Forum Standard (2001) *www.netlib.org/blas/blast-forum*

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 2.2.1.4 of 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: **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*.

6: **incx** – Integer *Input*

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

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

7: **y**[dim] – const double *Input*

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*.

8: **incy** – Integer *Input*

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

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

9: **beta** – double *Input*

On entry: the scalar β.

10: **ap**[dim] – double *Input/Output*

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 $i \geq j$.

On exit: the updated matrix *A*.

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

The NAG error argument (see Section 2.6 of 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** = ⟨*value*⟩.
Constraint: **incy** $\neq 0$.

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

7 Accuracy

The BLAS standard requires accurate implementations which avoid unnecessary over/underflow (see Section 2.7 of The BLAS Technical Forum Standard (2001)).

8 Further Comments

None.

9 Example

Perform rank-2 update of real symmetric matrix A, stored in packed storage format, using vectors x and y:

$$A \leftarrow A - xy^{\mathrm{T}} - yx^{\mathrm{T}},$$

where A is the 4 by 4 matrix given by

$$A = \begin{pmatrix} 4.30 & 4.00 & 0.40 & -0.28 \\ 4.00 & -4.87 & 0.31 & 0.07 \\ 0.40 & 0.31 & -8.02 & -5.95 \\ -0.28 & 0.07 & -5.95 & 0.12 \end{pmatrix},$$

$$x = (2.0, 2.0, 0.2, -0.14)^{\mathrm{T}} \quad \text{and} \quad y = (1.0, 1.0, 0.1, -0.07)^{\mathrm{T}}.$$

The vector y is stored in every second element of the array **y** (**incy** $= 2$).

9.1 Program Text

```
/* nag_dspr2 (f16psc) 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 ap_len, 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);

  Vprintf( "nag_dspr2 (f16psc) Example Program Results\n\n");

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

  /* Read the problem dimension */
  Vscanf("%ld%*[^\n] ", &n);

  /* Read the uplo storage parameter */
  Vscanf("%s%*[^\n] ", nag_enum_arg);
  /* nag_enum_name_to_value(x04nac).
   * Converts NAG enum member name to value
   */
  uplo = nag_enum_name_to_value(nag_enum_arg);

  /* Read scalar parameters */
  Vscanf("%lf%lf%*[^\n] ", &alpha, &beta);
  /* Read increment parameter */
  Vscanf("%ld%ld%*[^\n] ", &incx, &incy);

  ap_len = 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(ap_len, double)) ||
           !(x = NAG_ALLOC(xlen, double)) ||
           !(y = NAG_ALLOC(ylen, double)))
        {
          Vprintf("Allocation failure\n");
          exit_status = -1;
          goto END;
        }
    }
  else
    {
      Vprintf("Invalid n\n");
      exit_status = 1;
      return exit_status;
    }

  /* Input matrix A and vector x */

  if (uplo == Nag_Upper)
    {
      for (i = 1; i <= n; ++i)
        {
          for (j = i; j <= n; ++j)
            Vscanf("%lf", &A_UPPER(i,j));
          Vscanf("%*[^\n] ");
        }
    }
  else
    {
      for (i = 1; i <= n; ++i)
        {
          for (j = 1; j <= i; ++j)
            Vscanf("%lf", &A_LOWER(i,j));
          Vscanf("%*[^\n] ");
        }
    }
```

```
  for (i = 0; i < xlen; ++i)
    Vscanf("%lf%*[^\n] ", &x[i]);
  for (i = 0; i < ylen; ++i)
    Vscanf("%lf%*[^\n] ", &y[i]);

  /* nag_dspr2(f16psc).
   * Rank two update of real symmetric matrix,
   * packed storage.
   */
  nag_dspr2(order, uplo, n, alpha, x, incx, y, incy, beta, ap, &fail);
  if (fail.code != NE_NOERROR)
    {
      Vprintf("Error from nag_dspr2.\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }

  /* Print updated matrix A */
  /* nag_pack_real_mat_print (x04ccc).
   * Print real packed triangular matrix (easy-to-use)
   */
  nag_pack_real_mat_print(order, uplo, Nag_NonUnitDiag, n, ap,
                          "Updated Matrix A", 0, &fail);
  if (fail.code != NE_NOERROR)
    {
      Vprintf("Error from nag_pack_real_mat_print (x04ccc).\n%s\n",
              fail.message);
      exit_status = 1;
      goto END;
    }

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

  return exit_status;
}
```

9.2 Program Data

```
nag_dspr2 (f16psc) Example Program Data
  4                           :Value of n
  Nag_Lower                   :Storage of A
 -1.0    1.0                  :Values of alpha and beta
  1  2                        :Values of incx and incy
  4.30
  4.00  -4.87
  0.40   0.31  -8.02
 -0.28   0.07  -5.95   0.12   :End of matrix A
  2.00
  2.00
  0.20
 -0.14                        :End of vector x
  1.00
  0.00
  1.00
  0.00
  0.10
  0.00
 -0.07                        :End of vector y
```

9.3 Program Results

```
nag_dspr2 (f16psc) Example Program Results

 Updated Matrix A

             1           2           3           4
 1      0.3000
```

```
 2      0.0000     -8.8700
 3      0.0000     -0.0900     -8.0600
 4      0.0000      0.3500     -5.9220      0.1004
```