NAG 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

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

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: $\mathbf{incx} \neq 0$.

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: $\mathbf{incy} \neq 0$.

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

On exit: the updated matrix A.

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

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

6 Error Indicators and Warnings

NE_BAD_PARAM

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

NE_INT

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

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

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** $= 2$).

10.1 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);

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

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

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

  /* Read the uplo storage 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 scalar parameters */
  scanf("%lf%lf%*[^\n] ", &alpha, &beta);
  /* Read increment parameter */
  scanf("%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)))
        {
          printf("Allocation failure\n");
          exit_status = -1;
          goto END;
        }
    }
  else
    {
      printf("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)
            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] ");
        }
    }
  for (i = 0; i < xlen; ++i)
    scanf("%lf%*[^\n] ", &x[i]);
  for (i = 0; i < ylen; ++i)
    scanf("%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)
    {
      printf("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)
   */
  fflush(stdout);
  nag_pack_real_mat_print(order, uplo, Nag_NonUnitDiag, n, ap,
                          "Updated Matrix A", 0, &fail);
  if (fail.code != NE_NOERROR)
    {
      printf("Error from nag_pack_real_mat_print (x04ccc).\n%s\n",
             fail.message);
      exit_status = 1;
      goto END;
    }

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

  return exit_status;
}
```

10.2 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
```

10.3 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
```