nag_real_symm_eigenvalues (f02aac)

1. Purpose

nag_real_symm_eigenvalues (f02aac) calculates all the eigenvalues of a real symmetric matrix.

2. Specification

```
#include <nag.h>
#include <nagf02.h>

void nag_real_symm_eigenvalues(Integer n, double a[], Integer tda,
     double r[], NagError *fail)
```

3. Description

This function reduces the real symmetric matrix A to a real symmetric tridiagonal matrix using Householder's method. The eigenvalues of the tridiagonal matrix are then determined using the QL algorithm.

4. Parameters

n

Input: n, the order of the matrix A.
Constraint: $\mathbf{n} \geq 1$.

a[n][tda]

Input: the lower triangle of the n by n symmetric matrix A. The elements of the array above the diagonal need not be set.
Output: the elements of A below the diagonal are overwritten, and the rest of the array is unchanged.

tda

Input: the second dimension of the array **a** as declared in the function from which nag_real_symm_eigenvalues is called.
Constraint: $\mathbf{tda} \geq \mathbf{n}$.

r[n]

Output: the eigenvalues in ascending order.

fail

The NAG error parameter, see the Essential Introduction to the NAG C Library.

5. Error Indications and Warnings

NE_TOO_MANY_ITERATIONS

More than ⟨*value*⟩ iterations are required to isolate all the eigenvalues.

NE_INT_ARG_LT

On entry, **n** must not be less than 1: $\mathbf{n} = \langle value \rangle$.

NE_2_INT_ARG_LT

On entry, $\mathbf{tda} = \langle value \rangle$ while $\mathbf{n} = \langle value \rangle$. These parameters must satisfy $\mathbf{tda} \geq \mathbf{n}$.

NE_ALLOC_FAIL

Memory allocation failed.

6. Further Comments

The time taken by the function is approximately proportional to n^3.

6.1. Accuracy

The accuracy of the eigenvalues depends on the sensitivity of the matrix to rounding errors produced in tridiagonalisation. For a detailed error analysis see Wilkinson and Reinsch (1971) pp 222 and 235.

6.2. References

Wilkinson J H and Reinsch C (1971) *Handbook for Automatic Computation (Vol II, Linear Algebra)* Springer-Verlag pp 212–226 and 227–240.

7. See Also

None.

8. Example

To calculate all the eigenvalues of the real symmetric matrix

$$\begin{pmatrix} 0.5 & 0.0 & 2.3 & -2.6 \\ 0.0 & 0.5 & -1.4 & -0.7 \\ 2.3 & -1.4 & 0.5 & 0.0 \\ -2.6 & -0.7 & 0.0 & 0.5 \end{pmatrix}.$$

8.1. Program Text

```
/* nag_real_symm_eigenvalues(f02aac) Example Program
 *
 * Copyright 1990 Numerical Algorithms Group.
 *
 * Mark 1, 1990.
 */

#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagf02.h>

#define NMAX 8
#define TDA NMAX


main()
{
  Integer  i, j, n;
  double a[NMAX][TDA], r[NMAX];

  Vprintf("f02aac Example Program Results\n");
  /* Skip heading in data file */
  Vscanf("%*[^\n]");
  Vscanf("%ld",&n);

  if (n<1 || n>NMAX)
    {
      Vfprintf(stderr, "N is out of range: N = %5ld\n", n);
      exit(EXIT_FAILURE);
    }
  for (i=0; i<n; i++)
    for (j=0; j<n; j++)
      Vscanf("%lf",&a[i][j]);
  f02aac(n, (double *)a, (Integer)TDA, r, NAGERR_DEFAULT);
  Vprintf("Eigenvalues\n");
  for (i=0; i<n; i++)
    Vprintf("%9.4f%s",r[i],(i%8==7 || i==n-1) ? "\n": " ");
  exit(EXIT_SUCCESS);
}
```

8.2. Program Data

```
f02aac Example Program Data
  4
  0.5  0.0  2.3 -2.6
  0.0  0.5 -1.4 -0.7
  2.3 -1.4  0.5  0.0
 -2.6 -0.7  0.0  0.5
```

8.3. Program Results

```
f02aac Example Program Results
Eigenvalues
  -3.0000   -1.0000    2.0000    4.0000
```