NAG Library Routine Document

F06QRF

Note: before using this routine, please read the Users' Note for your implementation to check the interpretation of ***bold italicised*** terms and other implementation-dependent details.

1 Purpose

F06QRF performs a QR or RQ factorization (as a sequence of plane rotations) of a real upper Hessenberg matrix.

2 Specification

```
SUBROUTINE F06QRF (SIDE, N, K1, K2, C, S, A, LDA)
INTEGER            N, K1, K2, LDA
REAL (KIND=nag_wp) C(K2-1), S(K2-1), A(LDA,*)
CHARACTER(1)       SIDE
```

3 Description

F06QRF transforms an n by n real upper Hessenberg matrix H to upper triangular form R by applying an orthogonal matrix P from the left or the right. H is assumed to have nonzero subdiagonal elements $h_{k+1,k}$, for $k = k_1, \ldots, k_2 - 1$, only. P is formed as a sequence of plane rotations in planes k_1 to k_2.

If SIDE = 'L', the rotations are applied from the left:

$$PH = R,$$

where $P = P_{k_2-1} \cdots P_{k_1+1} P_{k_1}$.

If SIDE = 'R', the rotations are applied from the right:

$$HP^{\mathrm{T}} = R,$$

where $P = P_{k_1} P_{k_1+1} \cdots P_{k_2-1}$.

In either case, P_k is a rotation in the $(k, k+1)$ plane, chosen to annihilate $h_{k+1,k}$.

The 2 by 2 plane rotation part of P_k has the form

$$\begin{pmatrix} c_k & s_k \\ -s_k & c_k \end{pmatrix}.$$

4 References

None.

5 Arguments

1: SIDE – CHARACTER(1) *Input*

On entry: specifies whether H is operated on from the left or the right.

SIDE = 'L'
H is pre-multiplied from the left.

SIDE = 'R'
H is post-multiplied from the right.

Constraint: SIDE = 'L' or 'R'.

2: N – INTEGER *Input*

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

Constraint: $\mathrm{N} \geq 0$.

3: K1 – INTEGER *Input*

4: K2 – INTEGER *Input*

On entry: the values k_1 and k_2.

If $\mathrm{K1} < 1$ or $\mathrm{K2} \leq \mathrm{K1}$ or $\mathrm{K2} > \mathrm{N}$, an immediate return is effected.

5: C(K2 − 1) – REAL (KIND=nag_wp) array *Output*

On exit: $\mathrm{C}(k)$ holds c_k, the cosine of the rotation P_k, for $k = k_1, \ldots, k_2 - 1$.

6: S(K2 − 1) – REAL (KIND=nag_wp) array *Input/Output*

On entry: the nonzero subdiagonal elements of H: $\mathrm{S}(k)$ must hold $h_{k+1,k}$, for $k = k_1, \ldots, k_2 - 1$.

On exit: $\mathrm{S}(k)$ holds s_k, the sine of the rotation P_k, for $k = k_1, \ldots, k_2 - 1$.

7: A(LDA, ∗) – REAL (KIND=nag_wp) array *Input/Output*

Note: the second dimension of the array A must be at least N.

On entry: the upper triangular part of the n by n upper Hessenberg matrix H.

On exit: the upper triangular matrix R.

8: LDA – INTEGER *Input*

On entry: the first dimension of the array A as declared in the (sub)program from which F06QRF is called.

Constraint: $\mathrm{LDA} \geq \max(1, \mathrm{N})$.

6 Error Indicators and Warnings

None.

7 Accuracy

Not applicable.

8 Parallelism and Performance

F06QRF is not threaded in any implementation.

9 Further Comments

None.

10 Example

None.