NAG Library Routine Document

F06QPF

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

F06QPF performs a QR factorization (as a sequence of plane rotations) of a real upper triangular matrix that has been modified by a rank-1 update.

2 Specification

```
SUBROUTINE F06QPF (N, ALPHA, X, INCX, Y, INCY, A, LDA, C, S)

INTEGER            N, INCX, INCY, LDA
REAL (KIND=nag_wp) ALPHA, X(*), Y(*), A(LDA,*), C(N-1), S(N-1)
```

3 Description

F06QPF performs a QR factorization of an upper triangular matrix which has been modified by a rank-1 update:

$$\alpha x y^{\mathrm{T}} + U = QR$$

where U and R are n by n real upper triangular matrices, x and y are n-element real vectors, α is a real scalar, and Q is an n by n real orthogonal matrix.

Q is formed as the product of two sequences of plane rotations:

$$Q^{\mathrm{T}} = Q_{n-1} \cdots Q_2 Q_1 P_1 P_2 \cdots P_{n-1}$$

where

P_k is a rotation in the (k,n) plane, chosen to annihilate x_k: thus $Px = \beta e_n$, where $P = P_1 P_2 \cdots P_{n-1}$ and e_n is the last column of the unit matrix;

Q_k is a rotation in the (k,n) plane, chosen to annihilate the (n,k) element of $(\alpha\beta e_n y^{\mathrm{T}} + PU)$, and thus restore it to upper triangular form.

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

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

The tangents of the rotations P_k are returned in the array X; the cosines and sines of these rotations can be recovered by calling F06BCF. The cosines and sines of the rotations Q_k are returned directly in the arrays C and S.

4 References

None.

5 Arguments

1: N – INTEGER *Input*

On entry: n, the order of the matrices U and R.

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

2: ALPHA – REAL (KIND=nag_wp) *Input*

On entry: the scalar α.

3: X($*$) – REAL (KIND=nag_wp) array *Input/Output*

Note: the dimension of the array X must be at least $\max(1, 1 + (\mathrm{N} - 1) \times \mathrm{INCX})$.

On entry: the n-element vector x. x_i must be stored in $\mathrm{X}(1 + (i - 1) \times \mathrm{INCX})$, for $i = 1, 2, \ldots, \mathrm{N}$.

Intermediate elements of X are not referenced.

On exit: the referenced elements are overwritten by details of the sequence of plane rotations.

4: INCX – INTEGER *Input*

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

Constraint: $\mathrm{INCX} > 0$.

5: Y($*$) – REAL (KIND=nag_wp) array *Input*

Note: the dimension of the array Y must be at least $\max(1, 1 + (\mathrm{N} - 1) \times \mathrm{INCY})$.

On entry: the n-element vector y. y_i must be stored in $\mathrm{Y}(1 + (i - 1) \times \mathrm{INCY})$, for $i = 1, 2, \ldots, \mathrm{N}$.

Intermediate elements of Y are not referenced.

6: INCY – INTEGER *Input*

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

Constraint: $\mathrm{INCY} > 0$.

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 n by n upper triangular matrix U.

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 F06QPF is called.

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

9: C(N – 1) – REAL (KIND=nag_wp) array *Output*

On exit: the cosines of the rotations Q_k, for $k = 1, 2, \ldots, n - 1$.

10: S(N – 1) – REAL (KIND=nag_wp) array *Output*

On exit: the sines of the rotations Q_k, for $k = 1, 2, \ldots, n - 1$.

6 Error Indicators and Warnings

None.

7 Accuracy

Not applicable.

8 Parallelism and Performance

F06QPF makes calls to BLAS and/or LAPACK routines, which may be threaded within the vendor library used by this implementation. Consult the documentation for the vendor library for further information.

Please consult the X06 Chapter Introduction for information on how to control and interrogate the OpenMP environment used within this routine. Please also consult the Users' Note for your implementation for any additional implementation-specific information.

9 Further Comments

None.

10 Example

None.