NAG Toolbox for MATLAB

f08cg

1 Purpose

f08cg multiplies a general real m by n matrix C by the real orthogonal matrix Q from a QL factorization computed by f08ce.

2 Syntax

```
[c, info] = f08cg(side, trans, a, tau, c, 'm', m, 'n', n, 'k', k)
```

3 Description

f08cg is intended to be used following a call to f08ce, which performs a QL factorization of a real matrix A and represents the orthogonal matrix Q as a product of elementary reflectors.

This function may be used to form one of the matrix products

$$QC, \quad Q^{\mathrm{T}}C, \quad CQ, \quad CQ^{\mathrm{T}},$$

overwriting the result on C, which may be any real rectangular m by n matrix.

A common application of this function is in solving linear least squares problems, as described in the F08 Chapter Introduction, and illustrated in Section 9 of the document for f08ce.

4 References

Anderson E, Bai Z, Bischof C, Blackford S, Demmel J, Dongarra J J, Du Croz J J, Greenbaum A, Hammarling S, McKenney A and Sorensen D 1999 *LAPACK Users' Guide* (3rd Edition) SIAM, Philadelphia URL: http://www.netlib.org/lapack/lug

5 Parameters

5.1 Compulsory Input Parameters

1: **side – string**

Indicates how Q or Q^{T} is to be applied to C.

side = 'L'

Q or Q^{T} is applied to C from the left.

side = 'R'

Q or Q^{T} is applied to C from the right.

Constraint: **side** = 'L' or 'R'.

2: **trans – string**

Indicates whether Q or Q^{T} is to be applied to C.

trans = 'N'

Q is applied to C.

trans = 'T'

Q^{T} is applied to C.

Constraint: **trans** = 'N' or 'T'.

3: **a**(**lda**,∗) – **double array**

The first dimension, **lda**, of the array **a** must satisfy

if **side** = 'L', **lda** $\geq \max(1, \mathbf{m})$;
if **side** = 'R', **lda** $\geq \max(1, \mathbf{n})$.

The second dimension of the array must be at least $\max(1, \mathbf{k})$

Details of the vectors which define the elementary reflectors, as returned by f08ce.

4: **tau**(∗) – **double array**

Note: the dimension of the array **tau** must be at least $\max(1, \mathbf{k})$.

Further details of the elementary reflectors as returned by f08ce.

5: **c**(**ldc**,∗) – **double array**

The first dimension of the array **c** must be at least $\max(1, \mathbf{m})$

The second dimension of the array must be at least $\max(1, \mathbf{n})$

The m by n matrix C.

5.2 Optional Input Parameters

1: **m** – **int32 scalar**

Default: The first dimension of the array **c**.

m, the number of rows of the matrix C.

Constraint: $\mathbf{m} \geq 0$.

2: **n** – **int32 scalar**

Default: The second dimension of the array **c**.

n, the number of columns of the matrix C.

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

3: **k** – **int32 scalar**

Default: The second dimension of the array **a** The dimension of the array **tau**.

k, the number of elementary reflectors whose product defines the matrix Q.

Constraints:

if **side** = 'L', $\mathbf{m} \geq \mathbf{k} \geq 0$;
if **side** = 'R', $\mathbf{n} \geq \mathbf{k} \geq 0$.

5.3 Input Parameters Omitted from the MATLAB Interface

lda, ldc, work, lwork

5.4 Output Parameters

1: **c**(**ldc**,∗) – **double array**

The first dimension of the array **c** must be at least $\max(1, \mathbf{m})$

The second dimension of the array must be at least $\max(1, \mathbf{n})$

c contains QC or $Q^{\mathrm{T}}C$ or CQ or CQ^{T} as specified by **side** and **trans**.

2: **info – int32 scalar**

info = 0 unless the function detects an error (see Section 6).

6 Error Indicators and Warnings

Errors or warnings detected by the function:

info = $-i$

If **info** = $-i$, parameter i had an illegal value on entry. The parameters are numbered as follows:

1: **side**, 2: **trans**, 3: **m**, 4: **n**, 5: **k**, 6: **a**, 7: **lda**, 8: **tau**, 9: **c**, 10: **ldc**, 11: **work**, 12: **lwork**, 13: **info**.

It is possible that **info** refers to a parameter that is omitted from the MATLAB interface. This usually indicates that an error in one of the other input parameters has caused an incorrect value to be inferred.

7 Accuracy

The computed result differs from the exact result by a matrix E such that

$$\|E\|_2 = O\epsilon\|C\|_2$$

where ϵ is the ***machine precision***.

8 Further Comments

The total number of floating point operations is approximately $2nk(2m-k)$ if **side** = 'L' and $2mk(2n-k)$ if **side** = 'R'.

The complex analogue of this function is f08cu.

9 Example

```
side = 'Left';
trans = 'Transpose';
a   =   [-0.2536561223671959,   -0.7751853859846198,   0.1094532397645297,
0.06960714430288747;
         -0.0956952802509345,  0.2275943648113135,  0.5121810603924651,  -
0.5958371552327169;
         -2.894845895288455,  0.2084279305583289,  -0.0952450839256265,  -
0.09745000202404246;
           -0.5041099118295458,  -1.581266529610948,  0.2476000680518517,
0.02227428617692399;
           1.921275206091976,  -1.053208461749375,  1.692758571755385,  -
0.5930528694606012;
          -0.8729501828758776,  0.9018026937371966,  0.213935545781127,  -
3.091585353827385];
tau = [1.863066450840819;
     1.179138368141079;
     1.487335114645626;
     1.16172932097152];
c = [-2.67, 0.41;
     -0.55, -3.1;
     3.34, -4.01;
     -0.77, 2.76;
     0.48, -6.17;
     4.1, 0.21];
[cOut, info] = f08cg(side, trans, a, tau, c)
```

```
cOut =
   -0.0215   -0.0135
    0.0053   -0.0030
```

```
   -4.4403    4.5603
   -3.7314   -0.0848
   -1.6032   -1.3912
   -0.0991   -6.9893
info =
           0
```