NAG Toolbox for MATLAB

f11gc

1 Purpose

f11gc is the third in a suite of three functions for the iterative solution of a symmetric system of simultaneous linear equations (see Golub and Van Loan 1996). f11gc returns information about the computations during an iteration and/or after this has been completed. The first function of the suite, f11ga, is a setup function; the second function, f11gb, is the proper iterative solver.

These three functions are suitable for the solution of large sparse symmetric systems of equations.

2 Syntax

```
[itn, stplhs, stprhs, anorm, sigmax, its, sigerr, ifail] = f11gc()
```

3 Description

f11gc returns information about the solution process. It can be called either during a monitoring step of f11gb or after f11gb has completed its tasks. Calling f11gc at any other time will result in an error condition being raised.

For further information you should read the documentation for f11ga and f11gb.

4 References

Golub G H and Van Loan C F 1996 *Matrix Computations* (3rd Edition) Johns Hopkins University Press, Baltimore

5 Parameters

5.1 Compulsory Input Parameters

None.

5.2 Optional Input Parameters

None.

5.3 Input Parameters Omitted from the MATLAB Interface

None.

5.4 Output Parameters

1: **itn – int32 scalar**

The number of iterations carried out by f11gb.

2: **stplhs – double scalar**

The current value of the left-hand side of the termination criterion used by f11gb.

3: **stprhs – double scalar**

The current value of the right-hand side of the termination criterion used by f11gb.

4: **anorm – double scalar**

The norm $\|A\|_1 = \|A\|_\infty$ when either it has been supplied to f11ga or it has been estimated by f11gb (see also Sections 3 and 5 of the document for f11ga).
Otherwise, **anorm** $= 0.0$ is returned.

5: **sigmax – double scalar**

The current estimate of the largest singular value $\sigma_1(\bar{A})$ of the preconditioned iteration matrix $\bar{A} = E^{-1}AE^{-\mathrm{T}}$, when either it has been supplied to f11ga or it has been estimated by f11gb (see also Sections 3 and 5 of the document for f11ga). Note that if **its** $<$ **itn** then **sigmax** contains the final estimate. If, on final exit from f11gb, **its** $=$ **itn**, then the estimation of $\sigma_1(\bar{A})$ may have not converged: in this case you should look at the value returned in **sigerr**.
Otherwise, **sigmax** $= 0.0$ is returned.

6: **its – int32 scalar**

The number of iterations employed so far in the computation of the estimate of $\sigma_1(\bar{A})$, the largest singular value of the preconditioned matrix $\bar{A} = E^{-1}AE^{-\mathrm{T}}$, when $\sigma_1(\bar{A})$ has been estimated by f11gb using the bisection method (see also Sections 3, 5 and 8 of the document for f11ga).
Otherwise, **its** $= 0$ is returned.

7: **sigerr – double scalar**

If $\sigma_1(\bar{A})$ has been estimated by f11gb using bisection,

$$\textbf{sigerr} = \max\left(\frac{\left|\sigma_1^{(k)} - \sigma_1^{(k-1)}\right|}{\sigma_1^{(k)}}, \frac{\left|\sigma_1^{(k)} - \sigma_1^{(k-2)}\right|}{\sigma_1^{(k)}}\right),$$

where $k =$ **its** denotes the iteration number. The estimation has converged if **sigerr** $\leq$ **sigtol** where **sigtol** is an input parameter to f11ga.
Otherwise, **sigerr** $= 0.0$ is returned.

8: **ifail – int32 scalar**

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

6 Error Indicators and Warnings

Errors or warnings detected by the function:

ifail $= 1$

f11gc has been called out of sequence. For example, the last call to f11gb did not return IREVCM $= 3$ or 4.

7 Accuracy

Not applicable.

8 Further Comments

None.

9 Example

```
method = 'CG';
```

```
precon = 'P';
n = int32(7);
tol = 1e-06;
maxitn = int32(20);
anorm = 0;
sigmax = 0;
maxits = int32(7);
monit = int32(2);
lfill = int32(0);
dtol = 0;
mic = 'N';
dscale = 0;
pstrat = 'M';
ipiv = zeros(n, 1, 'int32');
nnz = int32(16);
a = zeros(100, 1);
a(1:nnz) = [4, 1, 5, 2, 2, 3, -1, 1, 4, 1, -2, 3, 2, -1, -2, 5];
irow = zeros(100, 1, 'int32');
irow(1:nnz) = [int32(1), int32(2), int32(2), int32(3), int32(4), ...
               int32(4), int32(5), int32(5), int32(5), int32(6), ...
                      int32(6), int32(6), int32(7), int32(7), int32(7),
int32(7)];
icol = zeros(100, 1, 'int32');
icol(1:nnz) = [int32(1), int32(1), int32(2), int32(3), int32(2), ...
               int32(4), int32(1), int32(4), int32(5), int32(2), ...
                      int32(5), int32(6), int32(1), int32(2), int32(3),
int32(7)];
v = [15, 18, -8, 21, 11, 10, 29];
u = zeros(7, 1);
irevcm = int32(0);

% Calculate incomplete Cholesky factorisation
[a, irow, icol, ipiv, istr, nnzc, npivm, ifail] = ...
    f11ja(nnz, a, irow, icol, lfill, dtol, mic, dscale, ipiv);

% Initialise the solver
[lwreq, ifail] = ...
     f11ga(method, precon, n, tol, maxitn, anorm, sigmax, maxits, monit,
'norm_p', '1', 'sigcmp', 's');

work = zeros(lwreq, 1);

while (irevcm ~= 4)
  [irevcm, u, v, work, ifail] = f11gb(irevcm, u, v, work);

  if (irevcm == 1)
    % Calculate v = Au
    [v, ifail] = f11xe(a, irow, icol, 'No Checking', u, 'nnz', nnz);
    if (ifail ~= 0)
      irevcm = int32(6);
    end
  elseif (irevcm == 2)
    % Solve Mv = u
    [v, ifail] = f11jb(a, irow, icol, ipiv, istr, 'No Checking', u);
    if (ifail ~= 0)
      irevcm = int32(6);
    end
  elseif (irevcm == 3)
    % Display monitoring information
    [itn, stplhs, stprhs, anorm, sigmax, its, sigerr, ifail] = f11gc();
    if (ifail == 0)
      fprintf('\nMonitoring at iteration no. %d\n', itn);
      fprintf('residual norm: %14.4f\n', stplhs);
      fprintf('  Solution Vector  Residual Vector\n');
      for i=1:n
        fprintf('%16.4f %16.4f\n', u(i), v(i));
      end
    end
  end
end
```

```
% Obtain information about the computation
[itn, stplhs, stprhs, anorm, sigmax, its, sigerr, ifail] = f11gc();

% Print the output data
fprintf('\nFinal results\n');
fprintf('Number of iterations for convergence:        %d\n', itn);
fprintf('Residual norm:                              %14.4e\n', stplhs);
fprintf('Right-hand side of termination criteria: %14.4e\n', stprhs);
fprintf('1-norm of matrix A:                         %14.4e\n', anorm);
fprintf('Largest singular value of A_bar:            %14.4e\n', sigmax);
fprintf('  Solution Vector  Residual Vector\n');
for i=1:n
  fprintf('%16.4f %16.4f\n', u(i), v(i));
end
```

```
Monitoring at iteration no. 2
residual norm:         1.9938
  Solution Vector  Residual Vector
          0.9632          -0.2296
          1.9934           0.2225
          3.0583           0.0958
          4.1453          -0.2515
          4.8289          -0.1716
          5.6630           0.6753
          7.1062          -0.3474

Monitoring at iteration no. 4
residual norm:         0.0067
  Solution Vector  Residual Vector
          0.9994          -0.0011
          2.0011          -0.0025
          3.0008          -0.0000
          3.9996           0.0000
          4.9991           0.0021
          5.9993          -0.0009
          7.0007           0.0001
Final results
Number of iterations for convergence:        5
Residual norm:                               2.0428e-14
Right-hand side of termination criteria:     3.9200e-04
1-norm of matrix A:                          1.0000e+01
Largest singular value of A_bar:             1.3596e+00
Solution Vector  Residual Vector
1.0000           0.0000
          2.0000           0.0000
          3.0000          -0.0000
          4.0000          -0.0000
          5.0000          -0.0000
          6.0000           0.0000
          7.0000           0.0000
```