

NAG Toolbox for MATLAB

f11gt

1 Purpose

f11gt is the third in a suite of three functions for the iterative solution of a complex Hermitian system of simultaneous linear equations (see Golub and Van Loan 1996). f11gt returns information about the computations during an iteration and/or after this has been completed. The first function of the suite, f11gr, is a setup function, the second function, f11gs is the proper iterative solver.

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

2 Syntax

```
[itn, stplhs, stprhs, anorm, sigmax, its, sigerr, ifail] = f11gt(work,
'lwork', lwork)
```

3 Description

f11gt returns information about the solution process. It can be called either during a monitoring step of f11gs or after f11gs has completed its tasks. Calling f11gt at any other time will result in an error condition being raised.

For further information you should read the documentation for f11gr and f11gs.

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

1: **work(lwork)** – complex array

The workspace **work** as returned by f11gs (see also Section 3 of the document for f11gs).

5.2 Optional Input Parameters

1: **lwork** – int32 scalar

Default: The dimension of the array **work**.

Constraint: **lwork** $\geq$ 120.

Note: although the minimum value of **lwork** ensures the correct functioning of f11gt, a larger value is required by the iterative solver f11gs (see also Section 5 of the document for f11gr).

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 f11gs.

2: **stplhs** – double scalar

The current value of the left-hand side of the termination criterion used by f11gs.

3: **stprhs** – double scalar

The current value of the right-hand side of the termination criterion used by f11gs.

4: **anorm** – double scalar

The norm $\|A\|_1 = \|A\|_\infty$ when either it has been supplied to f11gr or it has been estimated by f11gs (see also Sections 3 and 5 of the document for f11gr). 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 $\bar{A} = E^{-1}AE^{-T}$, when either it has been supplied to f11gr or it has been estimated by f11gs (see also Sections 3 and 5 of the document for f11gr). Note that if **its** < **itn** then **sigmax** contains the final estimate. If, on final exit from f11gs, **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 $\bar{A} = E^{-1}AE^{-T}$, when $\sigma_1(\bar{A})$ has been estimated by f11gs using the bisection method (see also Sections 3, 5 and 8 of the document for f11gr). Otherwise, **its** = 0 is returned.

7: **sigerr** – double scalar

If $\sigma_1(\bar{A})$ has been estimated by f11gs using bisection,

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

where $k = \mathbf{its}$ denotes the iteration number. The estimation has converged if **sigerr** ≤ **sigtol** where **sigtol** is an input parameter to f11gr. 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 = −*i*

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

1: **itn**, 2: **stplhs**, 3: **stprhs**, 4: **anorm**, 5: **sigmax**, 6: **its**, 7: **sigerr**, 8: **work**, 9: **lwork**, 10: **ifail**.

ifail = 1

f11gt has been called out of sequence. For example, the last call to f11gs did not return **irevcn** = 3 or 4.

7 Accuracy

Not applicable.

8 Further Comments

None.

9 Example

```

nnz = int32(23);
a = zeros(10000,1);
a(1:nnz) = [complex( 6., 0.);
            complex(-1., 1.);
            complex( 6., 0.);
            complex( 0., 1.);
            complex( 5., 0.);
            complex( 5., 0.);
            complex( 2.,-2.);
            complex( 4., 0.);
            complex( 1., 1.);
            complex( 2., 0.);
            complex( 6., 0.);
            complex(-4., 3.);
            complex( 0., 1.);
            complex(-1., 0.);
            complex( 6., 0.);
            complex(-1.,-1.);
            complex( 0.,-1.);
            complex( 9., 0.);
            complex( 1., 3.);
            complex( 1., 2.);
            complex(-1., 0.);
            complex( 1., 4.);
            complex( 9., 0.)];
irow = zeros(10000, 1, 'int32');
irow(1:nnz) = [int32(1);
               int32(2);
               int32(2);
               int32(3);
               int32(3);
               int32(4);
               int32(5);
               int32(5);
               int32(6);
               int32(6);
               int32(6);
               int32(6);
               int32(7);
               int32(7);
               int32(7);
               int32(7);
               int32(8);
               int32(8);
               int32(8);
               int32(8);
               int32(9);
               int32(9);
               int32(9);
               int32(9);
               int32(9)];
icol = zeros(10000, 1, 'int32');
icol(1:nnz) = [int32(1);
               int32(1);
               int32(2);
               int32(2);
               int32(3);
               int32(4);
               int32(1);
               int32(5);
               int32(3);
               int32(4);
               int32(6);

```

```

        int32(2);
        int32(5);
        int32(6);
        int32(7);
        int32(4);
        int32(6);
        int32(8);
        int32(1);
        int32(5);
        int32(6);
        int32(8);
        int32(9)];
lfill = int32(0);
dtol = 0;
mic = 'N';
dscale = 0;
ipiv = [int32(0);
        int32(0);
        int32(0);
        int32(0);
        int32(0);
        int32(0);
        int32(0);
        int32(0)];
method = 'CG';
precon = 'P';
n = int32(9);
tol = 1e-06;
maxitn = int32(20);
anorm = 0;
sigmax = 0;
maxits = int32(9);
monit = int32(2);

irevcm = int32(0);
u = [complex(0, +0);
      complex(0, +0);
      complex(0, +0);
      complex(0, +0);
      complex(0, +0);
      complex(0, +0);
      complex(0, +0);
      complex(0, +0);
      complex(0, +0)];
v = [complex(8, +54);
      complex(-10, -92);
      complex(25, +27);
      complex(26, -28);
      complex(54, +12);
      complex(26, -22);
      complex(47, +65);
      complex(71, -57);
      complex(60, +70)];
wgt = [0; 0; 0; 0; 0; 0; 0; 0; 0];

[a, irow, icol, ipiv, istr, nnzc, npivm, ifail] = ...
    f11jn(nnzc, a, irow, icol, lfill, dtol, mic, dscale, ipiv);

[lwreq, work, ifail] = ...
    f11gr(method, precon, n, tol, maxitn, anorm, sigmax, maxits, monit,
    'sigcmp', 's', 'norm_p', '1');

while (irevcm ~= 4)
    [irevcm, u, v, work, ifail] = f11gs(irevcm, u, v, wgt, work);

    if (irevcm == 1)
        [v, ifail] = f11xs(a(1:nnzc), irow(1:nnzc), icol(1:nnzc), 'N', u);
        if (ifail ~= 0)

```

```

        irecvm = 6;
    end
elseif (irecvm == 2)
    [v, ifail] = f11jpa(a, irow, icol, ipiv, istr, 'N', u);
    if (ifail ~= 0)
        irecvm = 6;
    end
elseif (irecvm == 3)
    [itn, stplhs, stprhs, anorm, sigmax, its, sigerr, ifail] =
f11gt(work);
    if (ifail ~= 0)
        irecvm = 6;
    end
        fprintf('\nMonitoring at iteration number %d\nresidual norm:
%14.4e\n', itn, stplhs);
        for i = 1:n
            fprintf('%+16.4e + %+16.4eI\n', real(u(i)), imag(u(i)));
        end
        fprintf('\n    Residual Vector\n');
        for i = 1:n
            fprintf('%+16.4e + %+16.4eI\n', real(v(i)), imag(v(i)));
        end
    end
end

% Get information about the computation
[itn, stplhs, stprhs, anorm, sigmax, its, sigerr, ifail] = f11gt(work);
fprintf('\nNumber 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('i-norm of matrix a: %14.4e\n', anorm);
fprintf('\n    Solution Vector\n');
for i = 1:n
    fprintf('%+16.4e + %+16.4eI\n', real(u(i)), imag(u(i)));
end
fprintf('\n    Residual Vector\n');
for i = 1:n
    fprintf('%+16.4e + %+16.4eI\n', real(v(i)), imag(v(i)));
end

```

```

Monitoring at iteration number 2
residual norm: 1.4937e+01
+2.1423e-01 + +4.5333e+00I
-1.6589e+00 + -1.2672e+01I
+2.4101e+00 + +7.4551e+00I
+4.4400e+00 + -6.4174e+00I
+9.1135e+00 + +3.7812e+00I
+4.4419e+00 + -4.0382e+00I
+1.4757e+00 + +1.2662e+00I
+8.4872e+00 + -3.5347e+00I
+5.9948e+00 + +9.6851e-01I

```

```

Residual Vector
-1.8370e+00 + +3.6956e+00I
-6.5005e-01 + +2.5458e-01I
-1.2616e-01 + -1.3625e-01I
-1.3120e-01 + +1.4130e-01I
-1.1471e+00 + +7.3386e-01I
-5.5054e-01 + -1.0535e+00I
+1.7165e+00 + -1.4614e+00I
-3.5829e-01 + +2.8764e-01I
-3.0278e-01 + -3.5324e-01I

```

```

Monitoring at iteration number 4
residual norm: 1.4602e+00
+1.0061e+00 + +8.9847e+00I
+1.9637e+00 + -7.9768e+00I
+3.0067e+00 + +7.0285e+00I
+3.9830e+00 + -5.9636e+00I
+5.0390e+00 + +5.0432e+00I

```

```

+6.0488e+00 +      -4.0771e+00I
+6.9710e+00 +      +3.0168e+00I
+8.0118e+00 +      -1.9806e+00I
+9.0074e+00 +      +9.6458e-01I

Residual Vector
+1.1524e-02 +      -2.8188e-02I
+1.3513e-02 +      -1.7345e-01I
+1.8173e-02 +      +1.9627e-02I
+1.8900e-02 +      -2.0354e-02I
-9.0877e-02 +      -1.0895e-01I
-2.3890e-01 +      +3.2440e-01I
+1.9031e-01 +      -1.5499e-02I
+5.1611e-02 +      -4.1435e-02I
+4.3615e-02 +      +5.0884e-02I
Number of iterations for convergence: 5
Residual norm:                      9.0594e-14
Right-hand side of termination criteria: 2.7340e-03
i-norm of matrix a:                 2.2000e+01
Solution Vector
+1.0000e-00 +      +9.0000e+00I
+2.0000e+00 +      -8.0000e+00I
+3.0000e+00 +      +7.0000e+00I
+4.0000e+00 +      -6.0000e+00I
+5.0000e+00 +      +5.0000e+00I
+6.0000e+00 +      -4.0000e+00I
+7.0000e+00 +      +3.0000e+00I
+8.0000e+00 +      -2.0000e+00I
+9.0000e+00 +      +1.0000e+00I
Residual Vector
-1.7764e-15 +      +0.0000e+00I
+3.5527e-15 +      -2.8422e-14I
-3.5527e-15 +      +3.5527e-15I
+3.5527e-15 +      -7.1054e-15I
-7.1054e-15 +      +3.5527e-15I
-7.1054e-15 +      +0.0000e+00I
+0.0000e+00 +      +0.0000e+00I
+0.0000e+00 +      -7.1054e-15I
+0.0000e+00 +      -1.4211e-14I

```