NAG Toolbox for MATLAB

c05aj

1   Purpose

c05aj attempts to locate a zero of a continuous function using a continuation method based on a secant iteration.

2   Syntax

```
[x, ifail] = c05aj(x, eps, eta, f, nfmax)
```

3   Description

c05aj attempts to obtain an approximation to a simple zero α of the function $f(x)$ given an initial approximation x to α. The zero is found by a call to c05ax whose specification should be consulted for details of the method used.

The approximation x to the zero α is determined so that at least one of the following criteria is satisfied:

(i) $|x - \alpha| \sim \mathbf{eps}$,

(ii) $|f(x)| \leq \mathbf{eta}$.

4   References

None.

5   Parameters

5.1   Compulsory Input Parameters

1:     **x – double scalar**

An initial approximation to the zero.

2:     **eps – double scalar**

An absolute tolerance to control the accuracy to which the zero is determined. In general, the smaller the value of **eps** the more accurate **x** will be as an approximation to α. Indeed, for very small positive values of **eps**, it is likely that the final approximation will satisfy $|\mathbf{x} - \alpha| < \mathbf{eps}$. You are advised to call the function with more than one value for **eps** to check the accuracy obtained.

Constraint: **eps** > 0.0.

3:     **eta – double scalar**

A value such that if $|f(x)| < \mathbf{eta}$, x is accepted as the zero. **eta** may be specified as 0.0 (see Section 7).

4:     **f – string containing name of m-file**

f must evaluate the function f whose zero is to be determined.

Its specification is:

```
[result] = f(xx)
```

Input Parameters

1:     **xx – double scalar**

       The point at which the function must be evaluated.

Output Parameters

1:     **result – double scalar**

       The result of the function.

5:     **nfmax – int32 scalar**

       The maximum permitted number of calls to user-supplied real function **f** from c05aj. If **f** is inexpensive to evaluate, **nfmax** should be given a large value (say > 1000).

       Constraint: **nfmax** > 0.

5.2   Optional Input Parameters

None.

5.3   Input Parameters Omitted from the MATLAB Interface

None.

5.4   Output Parameters

1:     **x – double scalar**

       The final approximation to the zero, unless an error exit has occurred, in which case it contains no useful information.

2:     **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 $= 1$

       On entry, **eps** ≤ 0.0,
       or   **nfmax** ≤ 0.

ifail $= 2$

       An internally calculated scale factor has the wrong order of magnitude for the problem. If this error exit occurs, you are advised to call c05ax instead where different scale values can be tried.

ifail $= 3$

       Either the function $f(x)$ given by user-supplied real function **f** has no zero near **x** or too much accuracy has been requested in calculating the zero. The first is a more likely cause of this error exit and you should check the coding of **f** and make an independent investigation of its behaviour near **x**. The second can be alleviated by increasing **eps**.

ifail $= 4$

       More than **nfmax** calls have been made to the user-supplied real function **f**. This error exit can occur because **nfmax** is too small for the problem (essentially because **x** is too far away from the

zero) or for either of the reasons given under **ifail** $= 3$ above. If **nfmax** is increased considerably and this error exit occurs again at approximately the same final value of **x**, then it is likely that one of the reasons given under **ifail** $= 3$ is the cause.

ifail $= 5$ (c05ax)

A serious error has occurred in the specified function. Check all (sub)program calls. Seek expert help.

7 Accuracy

The levels of accuracy depend on the values of **eps** and **eta**. If full machine accuracy is required, they may be set very small, resulting in an exit with **ifail** $= 3$ or 4, although this may involve many more iterations than a lesser accuracy. You are recommended to set **eta** $= 0.0$ and to use **eps** to control the accuracy, unless you have considerable knowledge of the size of $f(x)$ for values of x near the zero.

8 Further Comments

The time taken by c05aj depends primarily on the time spent evaluating the function f (see Section 5) and on how close the initial value of **x** is to the zero.

If a more flexible way of specifying the function f is required or if you wish to have closer control of the calculation, then the reverse communication function c05ax is recommended instead of c05aj.

9 Example

```
c05aj_f.m

function [f] = c05ajf_f(x)
   f=exp(-x)-x;
```

```
x = 1;
eps = 0.001;
eta = 0;
nfmax = int32(200);
[xOut, ifail] = c05aj(x, eps, eta, 'c05aj_f', nfmax)

xOut =
    0.5672
ifail =
          0
```