NAG Library Routine Document

C09CAF

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

C09CAF computes the one-dimensional discrete wavelet transform (DWT) at a single level. The initialization routine C09AAF must be called first to set up the DWT options.

2 Specification

```
SUBROUTINE C09CAF (N, X, LENC, CA, CD, ICOMM, IFAIL)

INTEGER            N, LENC, ICOMM(100), IFAIL
REAL (KIND=nag_wp) X(N), CA(LENC), CD(LENC)
```

3 Description

C09CAF computes the one-dimensional DWT of a given input data array, x_i, for $i = 1, 2, \ldots, n$, at a single level. For a chosen wavelet filter pair, the output coefficients are obtained by applying convolution and downsampling by two to the input, x. The approximation (or smooth) coefficients, C_a, are produced by the low pass filter and the detail coefficients, C_d, by the high pass filter. To reduce distortion effects at the ends of the data array, several end extension methods are commonly used. Those provided are: periodic or circular convolution end extension, half-point symmetric end extension, whole-point symmetric end extension or zero end extension. The number n_c, of coefficients C_a or C_d is returned by the initialization routine C09AAF.

4 References

Daubechies I (1992) *Ten Lectures on Wavelets* SIAM, Philadelphia

5 Parameters

1: N – INTEGER *Input*

On entry: the number of elements, n, in the data array x.

Constraint: this must be the same as the value N passed to the initialization routine C09AAF.

2: X(N) – REAL (KIND=nag_wp) array *Input*

On entry: X contains the input dataset x_i, for $i = 1, 2, \ldots, n$.

3: LENC – INTEGER *Input*

On entry: the dimension of the arrays CA and CD as declared in the (sub)program from which C09CAF is called. This must be at least the number, n_c, of approximation coefficients, C_a, and detail coefficients, C_d, of the discrete wavelet transform as returned in NWC by the call to the initialization routine C09AAF.

Constraint: LENC $\geq n_c$, where n_c is the value returned in NWC by the call to the initialization routine C09AAF.

4: CA(LENC) – REAL (KIND=nag_wp) array *Output*

On exit: CA(i) contains the ith approximation coefficient, $C_a(i)$, for $i = 1, 2, \ldots, n_c$.

5: CD(LENC) – REAL (KIND=nag_wp) array *Output*

On exit: CD(i) contains the ith detail coefficient, $C_d(i)$, for $i = 1, 2, \ldots, n_c$.

6: ICOMM(100) – INTEGER array *Communication Array*

On entry: contains details of the discrete wavelet transform and the problem dimension as setup in the call to the initialization routine C09AAF.

On exit: contains additional information on the computed transform.

7: IFAIL – INTEGER *Input/Output*

On entry: IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this parameter you should refer to Section 3.3 in the Essential Introduction for details.

For environments where it might be inappropriate to halt program execution when an error is detected, the value -1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, if you are not familiar with this parameter, the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**

On exit: IFAIL $= 0$ unless the routine detects an error or a warning has been flagged (see Section 6).

6 Error Indicators and Warnings

If on entry IFAIL $= 0$ or -1, explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

IFAIL $= 1$

On entry, N is inconsistent with the value passed to the initialization routine C09AAF.

IFAIL $= 2$

On entry, LENC $< n_c$, where n_c is the value returned in NWC by the call to the initialization routine C09AAF.

IFAIL $= 6$

On entry, the initialization routine C09AAF has not been called first or it has been called with WTRANS $=$ 'M', or the communication array ICOMM has become corrupted.

7 Accuracy

The accuracy of the wavelet transform depends only on the floating point operations used in the convolution and downsampling and should thus be close to ***machine precision***.

8 Further Comments

None.

9 Example

This example computes the one-dimensional discrete wavelet decomposition for 8 values using the Daubechies wavelet, WAVNAM $=$ 'DB4', with zero end extension.

9.1 Program Text

```
    Program c09cafe

!     C09CAF Example Program Text

!     Mark 24 Release. NAG Copyright 2012.

!     .. Use Statements ..
      Use nag_library, Only: c09aaf, c09caf, c09cbf, nag_wp
!     .. Implicit None Statement ..
      Implicit None
!     .. Parameters ..
      Integer, Parameter               :: nin = 5, nout = 6
!     .. Local Scalars ..
      Integer                          :: ifail, n, nf, nwc, nwl, ny
      Character (12)                   :: mode, wavnam, wtrans
!     .. Local Arrays ..
      Real (Kind=nag_wp), Allocatable  :: ca(:), cd(:), x(:), y(:)
      Integer                          :: icomm(100)
!     .. Executable Statements ..
      Write (nout,*) 'C09CAF Example Program Results'
!     Skip heading in data file
      Read (nin,*)
!     Read problem parameters.
      Read (nin,*) n
      Read (nin,*) wavnam, mode
      Allocate (x(n),y(n))

      Write (nout,99999) wavnam, mode
!     Read array
      Read (nin,*) x(1:n)
      Write (nout,*) 'Input Data      X :'
      Write (nout,99997) x(1:n)
!     Query wavelet filter dimensions
      wtrans = 'Single Level'

!     ifail: behaviour on error exit
!            =0 for hard exit, =1 for quiet-soft, =-1 for noisy-soft
      ifail = 0
      Call c09aaf(wavnam,wtrans,mode,n,nwl,nf,nwc,icomm,ifail)

      Allocate (ca(nwc),cd(nwc))

      ifail = 0
      Call c09caf(n,x,nwc,ca,cd,icomm,ifail)

      Write (nout,99998)
      Write (nout,99997) ca(1:nwc)
      Write (nout,99996)
      Write (nout,99997) cd(1:nwc)

      ny = n

      ifail = 0
      Call c09cbf(nwc,ca,cd,ny,y,icomm,ifail)

      Write (nout,99995)
      Write (nout,99997) y(1:ny)

99999 Format (1X,'DWT :: Wavelet: ',A,', End mode: ',A)
99998 Format (1X,'Approximation coefficients CA : ')
99997 Format (1X,8(F8.4,1X):)
99996 Format (1X,'Detail coefficients        CD : ')
99995 Format (1X,'Reconstruction              Y : ')
    End Program c09cafe
```

9.2 Program Data

```
C09CAF Example Program Data
 8              : n
 DB4  Zero      : wavnam, mode
 1.0
 3.0
 5.0
 7.0
 6.0
 4.0
 5.0
 2.0            : x(1:n)
```

9.3 Program Results

```
 C09CAF Example Program Results
 DWT :: Wavelet: DB4         , End mode: Zero
 Input Data      X :
   1.0000   3.0000   5.0000   7.0000   6.0000   4.0000   5.0000   2.0000
 Approximation coefficients CA :
   0.0011  -0.0043  -0.0174   4.4778   8.9557   7.3401   2.5816
 Detail coefficients        CD :
   0.0237   0.0410  -0.5966   1.7763  -0.7517   0.3332  -0.1188
 Reconstruction              Y :
   1.0000   3.0000   5.0000   7.0000   6.0000   4.0000   5.0000   2.0000
```