

# NAG Library Routine Document

## C09ACF

**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

C09ACF returns the details of the chosen three-dimensional discrete wavelet filter. For a chosen mother wavelet, discrete wavelet transform type (single-level or multi-level DWT) and end extension method, this routine returns the maximum number of levels of resolution (appropriate to a multi-level transform), the filter length, the total number of coefficients and the number of wavelet coefficients in the second and third dimensions for the single-level case. This routine must be called before any of the three-dimensional transform routines in this chapter.

### 2 Specification

```
SUBROUTINE C09ACF (WAVNAM, WTRANS, MODE, M, N, FR, NWLMAX, NF, NWCT,      &
                  NWCN, NWCFR, ICOMM, IFAIL)
INTEGER          M, N, FR, NWLMAX, NF, NWCT, NWCN, NWCFR, ICOMM(260), IFAIL
CHARACTER(*)    WAVNAM
CHARACTER(1)    WTRANS, MODE
```

### 3 Description

Three-dimensional discrete wavelet transforms (DWT) are characterised by the mother wavelet, the end extension method and whether multiresolution analysis is to be performed. For the selected combination of choices for these three characteristics, and for given dimensions ( $m \times n \times fr$ ) of data array  $A$ , C09ACF returns the dimension details for the transform determined by this combination. The dimension details are:  $l_{\max}$ , the maximum number of levels of resolution that would be computed were a multi-level DWT applied;  $n_f$ , the filter length;  $n_{ct}$  the total number of wavelet coefficients (over all levels in the multi-level DWT case);  $n_{cn}$ , the number of coefficients in the second dimension for a single-level DWT; and  $n_{cfr}$ , the number of coefficients in the third dimension for a single-level DWT. These values are also stored in the communication array ICOMM, as are the input choices, so that they may be conveniently communicated to the three-dimensional transform routines in this chapter.

### 4 References

None.

### 5 Parameters

- 1: WAVNAM – CHARACTER(\*) *Input*  
*On entry:* the name of the mother wavelet. See the C09 Chapter Introduction for details.  
 WAVNAM = 'HAAR'  
     Haar wavelet.  
 WAVNAM = 'DB $n$ ', where  $n = 2, 3, \dots, 10$   
     Daubechies wavelet with  $n$  vanishing moments ( $2n$  coefficients). For example,  
     WAVNAM = 'DB4' is the name for the Daubechies wavelet with 4 vanishing moments  
     (8 coefficients).

WAVNAM = 'BIOR $x.y$ ', where  $x.y$  can be one of 1.1, 1.3, 1.5, 2.2, 2.4, 2.6, 2.8, 3.1, 3.3, 3.5 or 3.7

Biorthogonal wavelet of order  $x.y$ . For example WAVNAM = 'BIOR3.1' is the name for the biorthogonal wavelet of order 3.1.

*Constraint:* WAVNAM = 'HAAR', 'DB2', 'DB3', 'DB4', 'DB5', 'DB6', 'DB7', 'DB8', 'DB9', 'DB10', 'BIOR1.1', 'BIOR1.3', 'BIOR1.5', 'BIOR2.2', 'BIOR2.4', 'BIOR2.6', 'BIOR2.8', 'BIOR3.1', 'BIOR3.3', 'BIOR3.5' or 'BIOR3.7'.

2: WTRANS – CHARACTER(1) *Input*

*On entry:* the type of discrete wavelet transform that is to be applied.

WTRANS = 'S'

Single-level decomposition or reconstruction by discrete wavelet transform.

WTRANS = 'M'

Multiresolution, by a multi-level DWT or its inverse.

*Constraint:* WTRANS = 'S' or 'M'.

3: MODE – CHARACTER(1) *Input*

*On entry:* the end extension method.

MODE = 'P'

Periodic end extension.

MODE = 'H'

Half-point symmetric end extension.

MODE = 'W'

Whole-point symmetric end extension.

MODE = 'Z'

Zero end extension.

*Constraint:* MODE = 'P', 'H', 'W' or 'Z'.

4: M – INTEGER *Input*

*On entry:* the number of elements,  $m$ , in the first dimension (number of rows of each two-dimensional frame) of the input data,  $A$ .

*Constraint:*  $M \geq 2$ .

5: N – INTEGER *Input*

*On entry:* the number of elements,  $n$ , in the second dimension (number of columns of each two-dimensional frame) of the input data,  $A$ .

*Constraint:*  $N \geq 2$ .

6: FR – INTEGER *Input*

*On entry:* the number of elements,  $fr$ , in the third dimension (number of frames) of the input data,  $A$ .

*Constraint:*  $FR \geq 2$ .

7: NWLMAX – INTEGER *Output*

*On exit:* the maximum number of levels of resolution,  $l_{\max}$ , that can be computed if a multi-level discrete wavelet transform is applied (WTRANS = 'M'). It is such that  $2^{l_{\max}} \leq \min(m, n, fr) < 2^{l_{\max}+1}$ , for  $l_{\max}$  an integer.

If WTRANS = 'S', NWLMAX is not set.

- 8: NF – INTEGER *Output*  
*On exit:* the filter length,  $n_f$ , for the supplied mother wavelet. This is used to determine the number of coefficients to be generated by the chosen transform.
- 9: NWCT – INTEGER *Output*  
*On exit:* the total number of wavelet coefficients,  $n_{ct}$ , that will be generated. When WTRANS = 'S' the number of rows required (i.e., the first dimension of each two-dimensional frame) in each of the output coefficient arrays can be calculated as  $n_{cm} = n_{ct} / (8 \times n_{cn} \times n_{cfr})$ . When WTRANS = 'M' the length of the array used to store all of the coefficient matrices must be at least  $n_{ct}$ .
- 10: NWCN – INTEGER *Output*  
*On exit:* for a single-level transform (WTRANS = 'S'), the number of coefficients that would be generated in the second dimension,  $n_{cn}$ , for each coefficient type. For a multi-level transform (WTRANS = 'M') this is set to 1.
- 11: NWCFR – INTEGER *Output*  
*On exit:* for a single-level transform (WTRANS = 'S'), the number of coefficients that would be generated in the third dimension,  $n_{cfr}$ , for each coefficient type. For a multi-level transform (WTRANS = 'M') this is set to 1.
- 12: ICOMM(260) – INTEGER array *Communication Array*  
*On exit:* contains details of the wavelet transform and the problem dimension which is to be communicated to the two-dimensional discrete transform routines in this chapter.
- 13: 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, WAVNAM =  $\langle value \rangle$  was an illegal value.

IFAIL = 2

On entry, WTRANS =  $\langle value \rangle$  was an illegal value.

IFAIL = 3

On entry, MODE =  $\langle value \rangle$  was an illegal value.

IFAIL = 4

On entry, FR =  $\langle value \rangle$ .

Constraint:  $FR \geq 2$ .

On entry, M =  $\langle value \rangle$ .

Constraint:  $M \geq 2$ .

On entry, N =  $\langle value \rangle$ .

Constraint:  $N \geq 2$ .

IFAIL = -99

An unexpected error has been triggered by this routine. Please contact NAG.

See Section 3.8 in the Essential Introduction for further information.

IFAIL = -399

Your licence key may have expired or may not have been installed correctly.

See Section 3.7 in the Essential Introduction for further information.

IFAIL = -999

Dynamic memory allocation failed.

See Section 3.6 in the Essential Introduction for further information.

## 7 Accuracy

Not applicable.

## 8 Parallelism and Performance

Not applicable.

## 9 Further Comments

None.

## 10 Example

This example computes the three-dimensional multi-level resolution for  $8 \times 8 \times 8$  input data by a discrete wavelet transform using the Daubechies wavelet with four vanishing moments (see WAVNAM = 'DB4' in C09ACF) and zero end extension. The number of levels of transformation actually performed is one less than the maximum possible. This number of levels, the length of the wavelet filter, the total number of coefficients and the number of coefficients in each dimension for each level are printed along with the approximation coefficients before a reconstruction is performed. This example also demonstrates in general how to access any set of coefficients at any level following a multi-level transform.

### 10.1 Program Text

```

Program c09acfe

!      C09ACF Example Program Text
!      Mark 25 Release. NAG Copyright 2014.

!      .. Use Statements ..
!      Use nag_library, Only: c09acf, c09fcf, c09fdf, c09fyf, nag_wp, x02ajf
!      .. Implicit None Statement ..
!      Implicit None
!      .. Parameters ..

```

```

Integer, Parameter      :: nin = 5, nout = 6
! .. Local Scalars ..
Real (Kind=nag_wp)     :: eps, esq, frob
Integer                :: fr, i, ifail, j, k, lda, ldb, ldd, &
                        lenc, m, n, nf, nwcfr, nwcm, nwc, &
                        nwct, nwl, nwlmax, sda, sdb, sdd, &
                        want_coeffs, want_level
Character (10)         :: mode, wavnam, wtrans
Character (33)         :: title
! .. Local Arrays ..
Real (Kind=nag_wp), Allocatable :: a(:,:,:), b(:,:,:), c(:), d(:,:,:), &
e(:,:,:)
Integer, Allocatable  :: dwtlvfr(:), dwtlvm(:), dwtlvn(:)
Integer                :: icomm(260)
Character (3)         :: cpass(0:7)
! .. Intrinsic Procedures ..
Intrinsic              :: max, real, sqrt, sum
! .. Executable Statements ..
Continue
Write (nout,*) 'C09ACF Example Program Results'
Write (nout,*)
! Skip heading in data file
Read (nin,*)
! Read problem parameters
Read (nin,*) m, n, fr
Read (nin,*) wavnam, mode
lda = m
sda = n
ldb = m
sdb = n
Allocate (a(lda,sda,fr),b(ldb,sdb,fr),e(ldb,sdb,fr))

Write (nout,99999) wavnam, mode, m, n, fr

! Read data array and write it out

Do j = 1, fr
  Do i = 1, m
    Read (nin,*) a(i,1:n,j)
  End Do
  If (j<fr) Read (nin,*)
End Do

Write (nout,*) ' Input Data      A : '
Do j = 1, fr
  Do i = 1, m
    Write (nout,99998) a(i,1:n,j)
  End Do
  Write (nout,*)
End Do

! Query wavelet filter dimensions
! For Multi-Resolution Analysis, decomposition, wtrans = 'M'
wtrans = 'Multilevel'
ifail = 0
Call c09acf(wavnam,wtrans,mode,m,n,fr,nwlmax,nf,nwct,nwc,nwcfr,icom, &
  ifail)

! Transform one less than the max possible number of levels.
nwl = nwlmax - 1

lenc = nwct
Allocate (c(lenc),dwtlvm(nwl),dwtlvn(nwl),dwtlvfr(nwl))

! Perform Discrete Wavelet transform
ifail = 0
Call c09acf(m,n,fr,a,lda,sda,lenc,c,nwl,dwtlvm,dwtlvn,dwtlvfr,icom, &
  ifail)

! c09acf returns nwct based on max levels, so recalculate.
nwct = sum(7*dwtlvm(1:nwl)*dwtlvn(1:nwl)*dwtlvfr(1:nwl))

```

```

nwct = nwct + dwtlvm(1)*dwtlvn(1)*dwtlvfr(1)

Write (nout,99997) nwl
Write (nout,99988) nf
Write (nout,99987) nwct
Write (nout,99996)
Write (nout,99995) dwtlvm(1:nwl)
Write (nout,99994)
Write (nout,99995) dwtlvn(1:nwl)
Write (nout,99993)
Write (nout,99995) dwtlvfr(1:nwl)

!   Select the deepest level.
want_level = nwl
!   Select the approximation coefficients.
want_coeffs = 0

nwcm = dwtlvm(nwl-want_level+1)
nwcn = dwtlvn(nwl-want_level+1)
nwcfr = dwtlvfr(nwl-want_level+1)

!   Allocate space to store the coefficients
ldd = nwcm
sdd = nwcn
Allocate (d(ldd,sdd,nwcfr))

Write (nout,99986) want_level, nwcm, nwcn, nwcfr

cpass(0:7) = ('LLL','LLH','LHL','LHH','HLL','HLH','HHL','HHH')
If (want_coeffs==0) Then
  title = 'Approximation coefficients (LLL) '
Else
  title = 'Detail coefficients (' // cpass(want_coeffs) // ') '
End If

!   Extract the required coefficients
Call c09fyf(want_level,want_coeffs,lenc,c,d,ldd,sdd,icomm,ifail)

!   Print out the selected set of coefficients
Write (nout,99985) title
Write (nout,99989) want_level, want_coeffs
Do k = 1, nwcfr
  Write (nout,99990) k
  Do i = 1, nwcm
    Write (nout,99991) d(i,1:nwcn,k)
  End Do
End Do

Deallocate (d)

!   Reconstruct original data
ifail = 0
Call c09fdf(nwl,lenc,c,m,n,fr,b,ldb,sdb,icomm,ifail)

!   Check reconstruction matches original
eps = 10.0_nag_wp*real(m,kind=nag_wp)*real(n,kind=nag_wp)* &
  real(fr,kind=nag_wp)*x02ajf()

e(1:m,1:n,1:fr) = b(1:m,1:n,1:fr) - a(1:m,1:n,1:fr)
frob = 0.0_nag_wp
Do k = 1, fr
  esq = 0.0_nag_wp
  Do j = 1, n
    Do i = 1, m
      esq = esq + e(i,j,k)**2
    End Do
  End Do
  frob = max(frob,sqrt(esq))
End Do

If (frob>eps) Then

```

```

        Write (nout,99992)
    Else
        Write (nout,99992)
    End If

99999 Format (1X,' MLDWT :: Wavelet : ',A/1X,'          End mode : ',A/1X, &
        '      M      : ',I4/1X,'          N      : ',I4/1X, &
        '      FR      : ',I4/)
99998 Format (8(F8.4,1X):)
99997 Format (/1X,' Number of Levels :          ',I10)
99996 Format (1X,' Number of coefficients in 1st dimension for each level :')
99995 Format (8(I8,1X):)
99994 Format (1X,' Number of coefficients in 2nd dimension for each level :')
99993 Format (1X,' Number of coefficients in 3rd dimension for each level :')
99992 Format (/1X,' Success: the reconstruction matches the original.')
99991 Format (1X,8(F8.4,1X):)
99990 Format (1X,' Frame ',I2,' : ')
99989 Format (1X,' Level ',I2,', Coefficients ',I2,' : ')
99988 Format (1X,' Length of wavelet filter : ',I10)
99987 Format (1X,' Total number of wavelet coefficients : ',I10)
99986 Format (/1X,70('-')/1X,'Level : ',I10,'; output is ',I10,' by ',I10, &
        ' by ',I10/1X,70('-'))
99985 Format (/1X,A)
        End Program c09acfe

```

## 10.2 Program Data

C09ACF Example Program Data

8, 8, 8 : m, n, fr

DB4 zero : wavnam, mode

10.000	31.000	04.000	10.000	13.000	15.000	04.000	06.000
26.000	24.000	03.000	18.000	17.000	22.000	20.000	05.000
06.000	05.000	06.000	11.000	22.000	23.000	23.000	01.000
09.000	15.000	18.000	01.000	30.000	24.000	08.000	01.000
18.000	04.000	26.000	20.000	31.000	21.000	04.000	06.000
25.000	23.000	25.000	14.000	13.000	03.000	03.000	29.000
22.000	29.000	07.000	29.000	13.000	31.000	03.000	12.000
22.000	03.000	30.000	05.000	10.000	04.000	01.000	19.000
01.000	02.000	14.000	31.000	19.000	28.000	06.000	15.000
26.000	25.000	25.000	04.000	05.000	15.000	24.000	05.000
01.000	29.000	08.000	18.000	22.000	18.000	31.000	23.000
08.000	04.000	16.000	21.000	14.000	02.000	02.000	21.000
10.000	03.000	14.000	03.000	25.000	10.000	24.000	15.000
03.000	16.000	26.000	21.000	16.000	19.000	25.000	27.000
28.000	29.000	01.000	20.000	03.000	24.000	31.000	28.000
31.000	28.000	14.000	30.000	13.000	29.000	20.000	04.000
31.000	26.000	23.000	05.000	22.000	01.000	16.000	08.000
21.000	01.000	29.000	10.000	23.000	14.000	09.000	03.000
20.000	10.000	11.000	22.000	26.000	31.000	03.000	21.000
09.000	24.000	19.000	03.000	04.000	01.000	13.000	29.000
18.000	16.000	05.000	06.000	09.000	16.000	08.000	16.000
32.000	19.000	32.000	01.000	06.000	04.000	01.000	17.000
29.000	29.000	02.000	29.000	27.000	25.000	31.000	06.000
28.000	15.000	15.000	22.000	18.000	01.000	18.000	14.000
15.000	09.000	04.000	14.000	26.000	10.000	03.000	28.000
21.000	24.000	32.000	27.000	01.000	27.000	08.000	16.000
10.000	27.000	29.000	15.000	13.000	01.000	05.000	16.000
04.000	01.000	08.000	31.000	14.000	06.000	05.000	27.000
01.000	19.000	11.000	31.000	12.000	31.000	17.000	26.000
27.000	01.000	16.000	06.000	18.000	02.000	17.000	17.000
30.000	09.000	15.000	32.000	32.000	29.000	16.000	02.000
03.000	11.000	26.000	02.000	23.000	08.000	10.000	31.000
12.000	07.000	06.000	12.000	01.000	13.000	30.000	26.000
27.000	27.000	20.000	16.000	30.000	28.000	13.000	30.000
29.000	15.000	15.000	05.000	01.000	13.000	31.000	02.000
31.000	21.000	27.000	30.000	08.000	07.000	11.000	03.000

```

17.000 04.000 06.000 01.000 09.000 25.000 03.000 15.000
12.000 18.000 16.000 05.000 09.000 16.000 06.000 13.000
03.000 05.000 26.000 30.000 19.000 11.000 32.000 24.000
06.000 16.000 07.000 15.000 31.000 10.000 20.000 14.000

20.000 07.000 17.000 11.000 04.000 21.000 25.000 17.000
18.000 22.000 22.000 06.000 01.000 05.000 15.000 17.000
25.000 24.000 16.000 13.000 19.000 16.000 23.000 10.000
01.000 31.000 05.000 13.000 11.000 12.000 01.000 18.000
01.000 27.000 09.000 05.000 29.000 26.000 23.000 13.000
02.000 17.000 17.000 14.000 31.000 21.000 16.000 05.000
26.000 21.000 10.000 21.000 09.000 11.000 01.000 15.000
08.000 15.000 18.000 04.000 16.000 09.000 03.000 29.000

26.000 02.000 30.000 26.000 07.000 04.000 09.000 01.000
15.000 02.000 10.000 22.000 16.000 15.000 04.000 03.000
04.000 07.000 32.000 27.000 07.000 05.000 17.000 04.000
22.000 30.000 06.000 18.000 32.000 02.000 01.000 31.000
15.000 19.000 20.000 12.000 10.000 28.000 27.000 03.000
26.000 31.000 21.000 02.000 27.000 10.000 22.000 13.000
32.000 03.000 27.000 23.000 01.000 11.000 04.000 26.000
03.000 01.000 31.000 21.000 27.000 21.000 14.000 09.000

02.000 16.000 16.000 23.000 23.000 09.000 27.000 12.000
15.000 17.000 20.000 27.000 05.000 04.000 18.000 16.000
29.000 32.000 20.000 08.000 14.000 32.000 11.000 04.000
28.000 01.000 15.000 19.000 14.000 09.000 30.000 18.000
20.000 02.000 08.000 11.000 20.000 24.000 14.000 03.000
18.000 15.000 16.000 03.000 23.000 01.000 19.000 31.000
32.000 27.000 28.000 09.000 15.000 23.000 09.000 13.000
01.000 24.000 30.000 04.000 18.000 11.000 01.000 22.000

```

### 10.3 Program Results

C09ACF Example Program Results

```

MLDWT :: Wavelet : DB4
        End mode : zero
        M         : 8
        N         : 8
        FR        : 8

```

```

Input Data A :
10.0000 31.0000 4.0000 10.0000 13.0000 15.0000 4.0000 6.0000
26.0000 24.0000 3.0000 18.0000 17.0000 22.0000 20.0000 5.0000
6.0000 5.0000 6.0000 11.0000 22.0000 23.0000 23.0000 1.0000
9.0000 15.0000 18.0000 1.0000 30.0000 24.0000 8.0000 1.0000
18.0000 4.0000 26.0000 20.0000 31.0000 21.0000 4.0000 6.0000
25.0000 23.0000 25.0000 14.0000 13.0000 3.0000 3.0000 29.0000
22.0000 29.0000 7.0000 29.0000 13.0000 31.0000 3.0000 12.0000
22.0000 3.0000 30.0000 5.0000 10.0000 4.0000 1.0000 19.0000

1.0000 2.0000 14.0000 31.0000 19.0000 28.0000 6.0000 15.0000
26.0000 25.0000 25.0000 4.0000 5.0000 15.0000 24.0000 5.0000
1.0000 29.0000 8.0000 18.0000 22.0000 18.0000 31.0000 23.0000
8.0000 4.0000 16.0000 21.0000 14.0000 2.0000 2.0000 21.0000
10.0000 3.0000 14.0000 3.0000 25.0000 10.0000 24.0000 15.0000
3.0000 16.0000 26.0000 21.0000 16.0000 19.0000 25.0000 27.0000
28.0000 29.0000 1.0000 20.0000 3.0000 24.0000 31.0000 28.0000
31.0000 28.0000 14.0000 30.0000 13.0000 29.0000 20.0000 4.0000

31.0000 26.0000 23.0000 5.0000 22.0000 1.0000 16.0000 8.0000
21.0000 1.0000 29.0000 10.0000 23.0000 14.0000 9.0000 3.0000
20.0000 10.0000 11.0000 22.0000 26.0000 31.0000 3.0000 21.0000
9.0000 24.0000 19.0000 3.0000 4.0000 1.0000 13.0000 29.0000
18.0000 16.0000 5.0000 6.0000 9.0000 16.0000 8.0000 16.0000
32.0000 19.0000 32.0000 1.0000 6.0000 4.0000 1.0000 17.0000
29.0000 29.0000 2.0000 29.0000 27.0000 25.0000 31.0000 6.0000
28.0000 15.0000 15.0000 22.0000 18.0000 1.0000 18.0000 14.0000

```



```

15.0000  9.0000  4.0000  14.0000  26.0000  10.0000  3.0000  28.0000
21.0000  24.0000  32.0000  27.0000  1.0000  27.0000  8.0000  16.0000
10.0000  27.0000  29.0000  15.0000  13.0000  1.0000  5.0000  16.0000
 4.0000  1.0000  8.0000  31.0000  14.0000  6.0000  5.0000  27.0000
 1.0000  19.0000  11.0000  31.0000  12.0000  31.0000  17.0000  26.0000
27.0000  1.0000  16.0000  6.0000  18.0000  2.0000  17.0000  17.0000
30.0000  9.0000  15.0000  32.0000  32.0000  29.0000  16.0000  2.0000
 3.0000  11.0000  26.0000  2.0000  23.0000  8.0000  10.0000  31.0000

```

```

12.0000  7.0000  6.0000  12.0000  1.0000  13.0000  30.0000  26.0000
27.0000  27.0000  20.0000  16.0000  30.0000  28.0000  13.0000  30.0000
29.0000  15.0000  15.0000  5.0000  1.0000  13.0000  31.0000  2.0000
31.0000  21.0000  27.0000  30.0000  8.0000  7.0000  11.0000  3.0000
17.0000  4.0000  6.0000  1.0000  9.0000  25.0000  3.0000  15.0000
12.0000  18.0000  16.0000  5.0000  9.0000  16.0000  6.0000  13.0000
 3.0000  5.0000  26.0000  30.0000  19.0000  11.0000  32.0000  24.0000
 6.0000  16.0000  7.0000  15.0000  31.0000  10.0000  20.0000  14.0000

```

```

20.0000  7.0000  17.0000  11.0000  4.0000  21.0000  25.0000  17.0000
18.0000  22.0000  22.0000  6.0000  1.0000  5.0000  15.0000  17.0000
25.0000  24.0000  16.0000  13.0000  19.0000  16.0000  23.0000  10.0000
 1.0000  31.0000  5.0000  13.0000  11.0000  12.0000  1.0000  18.0000
 1.0000  27.0000  9.0000  5.0000  29.0000  26.0000  23.0000  13.0000
 2.0000  17.0000  17.0000  14.0000  31.0000  21.0000  16.0000  5.0000
26.0000  21.0000  10.0000  21.0000  9.0000  11.0000  1.0000  15.0000
 8.0000  15.0000  18.0000  4.0000  16.0000  9.0000  3.0000  29.0000

```

```

26.0000  2.0000  30.0000  26.0000  7.0000  4.0000  9.0000  1.0000
15.0000  2.0000  10.0000  22.0000  16.0000  15.0000  4.0000  3.0000
 4.0000  7.0000  32.0000  27.0000  7.0000  5.0000  17.0000  4.0000
22.0000  30.0000  6.0000  18.0000  32.0000  2.0000  1.0000  31.0000
15.0000  19.0000  20.0000  12.0000  10.0000  28.0000  27.0000  3.0000
26.0000  31.0000  21.0000  2.0000  27.0000  10.0000  22.0000  13.0000
32.0000  3.0000  27.0000  23.0000  1.0000  11.0000  4.0000  26.0000
 3.0000  1.0000  31.0000  21.0000  27.0000  21.0000  14.0000  9.0000

```

```

 2.0000  16.0000  16.0000  23.0000  23.0000  9.0000  27.0000  12.0000
15.0000  17.0000  20.0000  27.0000  5.0000  4.0000  18.0000  16.0000
29.0000  32.0000  20.0000  8.0000  14.0000  32.0000  11.0000  4.0000
28.0000  1.0000  15.0000  19.0000  14.0000  9.0000  30.0000  18.0000
20.0000  2.0000  8.0000  11.0000  20.0000  24.0000  14.0000  3.0000
18.0000  15.0000  16.0000  3.0000  23.0000  1.0000  19.0000  31.0000
32.0000  27.0000  28.0000  9.0000  15.0000  23.0000  9.0000  13.0000
 1.0000  24.0000  30.0000  4.0000  18.0000  11.0000  1.0000  22.0000

```

```

Number of Levels :                2
Length of wavelet filter :         8
Total number of wavelet coefficients :      5145
Number of coefficients in 1st dimension for each level :
 7          7
Number of coefficients in 2nd dimension for each level :
 7          7
Number of coefficients in 3rd dimension for each level :
 7          7

```

```

-----
Level :           2; output is           7 by           7 by           7
-----

```

```

Approximation coefficients (LLL)
Level 2, Coefficients 0 :
Frame 1 :
-0.0000 -0.0000  0.0000  0.0001  0.0000  0.0000
-0.0000 -0.0000  0.0000 -0.0001  0.0000 -0.0007 -0.0000
 0.0000  0.0000 -0.0001 -0.0002 -0.0020  0.0036 -0.0002
-0.0000 -0.0000 -0.0002  0.0021  0.0025 -0.0124  0.0010
 0.0001 -0.0000 -0.0017  0.0009  0.0928  0.1155  0.0004
 0.0002 -0.0007  0.0013 -0.0063  0.1584  0.0931  0.0096
 0.0000 -0.0001  0.0003 -0.0006  0.0123  0.0061  0.0014
Frame 2 :

```

```

-0.0000  0.0000  0.0000 -0.0000 -0.0010 -0.0005 -0.0000
 0.0000 -0.0000  0.0001 -0.0006  0.0026  0.0035  0.0004
 0.0001 -0.0000 -0.0008  0.0027  0.0133 -0.0064 -0.0032
-0.0002  0.0000  0.0032 -0.0067 -0.0708  0.0073  0.0148
-0.0003  0.0035 -0.0155  0.0406 -0.3676 -0.3434 -0.0682
-0.0011  0.0004  0.0241 -0.0866 -0.4993 -0.5807 -0.0674
-0.0002 -0.0003  0.0048 -0.0128 -0.0800 -0.0731 -0.0045
Frame 3 :
 0.0000  0.0000 -0.0002  0.0005  0.0006  0.0027  0.0005
-0.0000  0.0002 -0.0012  0.0037 -0.0224  0.0005 -0.0006
-0.0002 -0.0011  0.0067 -0.0126  0.0447 -0.0734  0.0068
 0.0008  0.0025 -0.0141 -0.0008  0.0872  0.3261 -0.0494
 0.0012 -0.0173  0.0687 -0.0681  0.5915 -0.1717  0.3943
 0.0016  0.0123 -0.1221  0.4190 -0.5269  1.2295  0.1617
 0.0003  0.0028 -0.0182  0.0396  0.1154  0.2823  0.0102
Frame 4 :
-0.0000 -0.0002  0.0011 -0.0030  0.0059 -0.0102 -0.0026
 0.0000 -0.0010  0.0042 -0.0106  0.0948 -0.0180 -0.0005
 0.0004  0.0061 -0.0296  0.0586 -0.3921  0.3650  0.0134
-0.0018 -0.0155  0.0684 -0.0636  0.5365 -1.4566  0.0298
-0.0070  0.0592 -0.1486 -0.1055 -2.9693  0.1109 -1.4193
-0.0017 -0.0424  0.2595 -0.7280  2.4682 -4.1771 -0.5119
 0.0003 -0.0079  0.0273 -0.0205 -0.1224 -0.9982 -0.0710
Frame 5 :
 0.0001 -0.0000 -0.0005 -0.0015  0.0804  0.1009  0.0139
-0.0006  0.0033 -0.0017 -0.0019 -0.5303 -0.5712 -0.0438
-0.0014 -0.0157  0.0800 -0.1856  0.4182  0.4931  0.0090
 0.0099  0.0522 -0.4140  1.1260  0.6111 -0.0042 -0.1288
 0.0831 -0.4718  0.9591 -2.9510 84.8494 91.3686 10.1751
 0.1599 -0.3194 -0.8962  1.8546 106.1903 117.2751 12.9904
 0.0213 -0.0211 -0.2179  0.4955 12.5323 12.9746  1.3422
Frame 6 :
 0.0002 -0.0004 -0.0006  0.0005  0.0945  0.1342  0.0157
-0.0008  0.0048 -0.0052  0.0013 -0.7012 -0.3668 -0.0231
-0.0006 -0.0125  0.0347 -0.0396  1.3945 -0.2227 -0.1395
 0.0034  0.0166 -0.0246 -0.0495 -3.2417 -0.3508  0.3284
 0.1373 -0.4804 -0.1436  0.6068 105.5811 101.7766 10.0719
 0.1359 -0.6132  0.8736 -2.8616 121.1074 124.4215 13.7050
 0.0068 -0.0939  0.4312 -1.4152 12.9366 13.1259  1.6024
Frame 7 :
 0.0000 -0.0001  0.0006 -0.0024  0.0134  0.0160  0.0014
-0.0001  0.0006  0.0003 -0.0044 -0.0813 -0.0377 -0.0021
 0.0006  0.0002 -0.0206  0.0816  0.0851 -0.0274 -0.0148
-0.0028 -0.0074  0.1035 -0.3488  0.0136 -0.1313  0.0288
 0.0177 -0.0358 -0.0968  0.1416 11.4442 11.6279  0.9779
 0.0187 -0.0759  0.0227  0.1041 13.7268 13.3069  1.5629
 0.0002 -0.0164  0.0748 -0.2042  1.6290  1.2827  0.1547

```

Success: the reconstruction matches the original.

---