

# NAG Library Function Document

## nag\_imldwt\_3d (c09fdc)

### 1 Purpose

nag\_imldwt\_3d (c09fdc) computes the inverse three-dimensional multi-level discrete wavelet transform (IDWT). This function reconstructs data from (possibly filtered or otherwise manipulated) wavelet transform coefficients calculated by nag\_mldwt\_3d (c09fcc) from an original input array. The initialization function nag\_wfilt\_3d (c09acc) must be called first to set up the IDWT options.

### 2 Specification

```
#include <nag.h>
#include <nagc09.h>

void nag_imldwt_3d (Integer nwlinv, Integer lenc, const double c[],
                   Integer m, Integer n, Integer fr, double b[], Integer ldb, Integer sdb,
                   const Integer icomm[], NagError *fail)
```

### 3 Description

nag\_imldwt\_3d (c09fdc) performs the inverse operation of nag\_mldwt\_3d (c09fcc). That is, given a set of wavelet coefficients, computed up to level  $n_{\text{fwd}}$  by nag\_mldwt\_3d (c09fcc) using a DWT as set up by the initialization function nag\_wfilt\_3d (c09acc), on a real three-dimensional array,  $A$ , nag\_imldwt\_3d (c09fdc) will reconstruct  $A$ . The reconstructed array is referred to as  $B$  in the following since it will not be identical to  $A$  when the DWT coefficients have been filtered or otherwise manipulated prior to reconstruction. If the original input array is level 0, then it is possible to terminate reconstruction at a higher level by specifying fewer than the number of levels used in the call to nag\_mldwt\_3d (c09fcc). This results in a partial reconstruction.

### 4 References

Wang Y, Che X and Ma S (2012) Nonlinear filtering based on 3D wavelet transform for MRI denoising *URASIP Journal on Advances in Signal Processing* **2012:40**

### 5 Arguments

- 1: **nwlinv** – Integer *Input*
- On entry:* the number of levels to be used in the inverse multi-level transform. The number of levels must be less than or equal to  $n_{\text{fwd}}$ , which has the value of argument **nwl** as used in the computation of the wavelet coefficients using nag\_mldwt\_3d (c09fcc). The data will be reconstructed to level (**nwl** – **nwlinv**), where level 0 is the original input dataset provided to nag\_mldwt\_3d (c09fcc).
- Constraint:*  $1 \leq \text{nwlinv} \leq \text{nwl}$ , where **nwl** is the value used in a preceding call to nag\_mldwt\_3d (c09fcc).
- 2: **lenc** – Integer *Input*
- On entry:* the dimension of the array **c**.
- Constraint:* **lenc**  $\geq n_{\text{ct}}$ , where  $n_{\text{ct}}$  is the total number of wavelet coefficients that correspond to a transform with **nwlinv** levels.

- 3: **c[lenc]** – const double *Input*  
*On entry:* the coefficients of the multi-level discrete wavelet transform. This will normally be the result of some transformation on the coefficients computed by function nag\_mldwt\_3d (c09fcc).  
 Note that the coefficients in **c** may be extracted according to level and type into three-dimensional arrays using nag\_wav\_3d\_coeff\_ext (c09fyc), and inserted using nag\_wav\_3d\_coeff\_ins (c09fzc).
- 4: **m** – Integer *Input*  
*On entry:* the number of elements,  $m$ , in the first dimension of the reconstructed array  $B$ . For a full reconstruction of **nwl** levels, where **nwl** is as supplied to nag\_mldwt\_3d (c09fcc), this must be the same as argument **m** used in a preceding call to nag\_mldwt\_3d (c09fcc). For a partial reconstruction of **nwl***inv* < **nwl** levels, this must be equal to **dwtlv***m*[**nwl***inv*], as returned from nag\_mldwt\_3d (c09fcc).
- 5: **n** – Integer *Input*  
*On entry:* the number of elements,  $n$ , in the second dimension of the reconstructed array  $B$ . For a full reconstruction of **nwl** levels, where **nwl** is as supplied to nag\_mldwt\_3d (c09fcc), this must be the same as argument **n** used in a preceding call to nag\_mldwt\_3d (c09fcc). For a partial reconstruction of **nwl***inv* < **nwl** levels, this must be equal to **dwtlv***n*[**nwl***inv*], as returned from nag\_mldwt\_3d (c09fcc).
- 6: **fr** – Integer *Input*  
*On entry:* the number of elements,  $fr$ , in the third dimension of the reconstructed array  $B$ . For a full reconstruction of **nwl** levels, where **nwl** is as supplied to nag\_mldwt\_3d (c09fcc), this must be the same as argument **fr** used in a preceding call to nag\_mldwt\_3d (c09fcc). For a partial reconstruction of **nwl***inv* < **nwl** levels, this must be equal to **dwtlv***fr*[**nwl***inv*], as returned from nag\_mldwt\_3d (c09fcc).
- 7: **b[dim]** – double *Output*  
**Note:** the dimension,  $dim$ , of the array **b** must be at least  $ldb \times sdb \times fr$ .  
*On exit:* the  $m$  by  $n$  by  $fr$  reconstructed array,  $B$ , with  $B_{ijk}$  stored in **b**[( $k - 1$ )  $\times$   $ldb \times sdb + (j - 1) \times ldb + i - 1$ ]. The reconstruction is based on the input multi-level wavelet transform coefficients and the transform options supplied to the initialization function nag\_wfilt\_3d (c09acc).
- 8: **ldb** – Integer *Input*  
*On entry:* the stride separating row elements of each of the sets of frame coefficients in the three-dimensional data stored in **b**.  
**Constraint:**  $ldb \geq m$ .
- 9: **sdb** – Integer *Input*  
*On entry:* the stride separating corresponding coefficients of consecutive frames in the three-dimensional data stored in **b**.  
**Constraint:**  $sdb \geq n$ .
- 10: **icomm[260]** – const Integer *Communication Array*  
*On entry:* contains details of the discrete wavelet transform and the problem dimension as setup in the call to the initialization function nag\_wfilt\_3d (c09acc).

11: **fail** – NagError \**Input/Output*

The NAG error argument (see Section 2.7 in How to Use the NAG Library and its Documentation).

## 6 Error Indicators and Warnings

### NE\_ALLOC\_FAIL

Dynamic memory allocation failed.

See Section 2.3.1.2 in How to Use the NAG Library and its Documentation for further information.

### NE\_BAD\_PARAM

On entry, argument  $\langle value \rangle$  had an illegal value.

### NE\_INITIALIZATION

Either the communication array **icom** has been corrupted or there has not been a prior call to the initialization function `nag_wfilt_3d (c09acc)`.

The initialization function was called with **wtrans** = Nag\_SingleLevel.

### NE\_INT

On entry, **fr** =  $\langle value \rangle$ .

Constraint: **fr**  $\geq \langle value \rangle$ , the number of coefficients in the third dimension at the required level of reconstruction.

On entry, **m** =  $\langle value \rangle$ .

Constraint: **m**  $\geq \langle value \rangle$ , the number of coefficients in the first dimension at the required level of reconstruction.

On entry, **n** =  $\langle value \rangle$ .

Constraint: **n**  $\geq \langle value \rangle$ , the number of coefficients in the second dimension at the required level of reconstruction.

On entry, **nwlinv** =  $\langle value \rangle$ .

Constraint: **nwlinv**  $\geq 1$ .

### NE\_INT\_2

On entry, **ldb** =  $\langle value \rangle$  and **m** =  $\langle value \rangle$ .

Constraint: **ldb**  $\geq \mathbf{m}$ .

On entry, **lenc** =  $\langle value \rangle$ .

Constraint: **lenc**  $\geq \langle value \rangle$ , the number of wavelet coefficients required for a transform operating on **nwlinv** levels. If **nwlinv** = **nwlmax**, the maximum number of levels as returned by the initial call to `nag_wfilt_3d (c09acc)`, then **lenc** must be at least  $n_{ct}$ , the value returned in **nwct** by the same call to `nag_wfilt_3d (c09acc)`.

On entry, **nwlinv** =  $\langle value \rangle$  and **nwl** =  $\langle value \rangle$  where **nwl** is as used in the computation of the wavelet coefficients by a call to `nag_mldwt_3d (c09fcc)`.

Constraint: **nwlinv**  $\leq \mathbf{nwl}$  as used in the call to `nag_mldwt_3d (c09fcc)`.

On entry, **sdb** =  $\langle value \rangle$  and **n** =  $\langle value \rangle$ .

Constraint: **sdb**  $\geq \mathbf{n}$ .

### NE\_INTERNAL\_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please contact NAG for assistance.

An unexpected error has been triggered by this function. Please contact NAG.  
See Section 2.7.6 in How to Use the NAG Library and its Documentation for further information.

#### **NE\_NO\_LICENCE**

Your licence key may have expired or may not have been installed correctly.  
See Section 2.7.5 in How to Use the NAG Library and its Documentation for further information.

### **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 Parallelism and Performance**

nag\_imldwt\_3d (c09fdc) is not threaded in any implementation.

### **9 Further Comments**

None.

### **10 Example**

See Section 10 in nag\_mldwt\_3d (c09fcc).

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