

nag_cwt_real

1. Purpose

nag_cwt_real computes the real, one-dimensional, continuous wavelet transform coefficients for an array of n real values at ns scales.

2. Specification

```
#include <nag.h>
#include <nag_wav.h>
void nag_cwt_real(Nag_WavType wavname, Integer wavparam, Integer n,
                 const double x[], Integer ns,
                 const Integer scales[], double coefs[], NagError *fail)
```

3. Description

nag_cwt_real computes the real part of the one-dimensional, continuous wavelet transform

$$C_{s,k} = \int_{\mathcal{R}} x(t) \frac{1}{\sqrt{s}} \psi^* \left(\frac{t-k}{s} \right) dt,$$

of a discrete signal $x(t)$ at scale s and position k . ψ is the wavelet function which can be chosen to be the Morlet wavelet, the Derivative of a Gaussian or the Mexican Hat wavelet. The integrals of the scaled, shifted wavelet function are approximated and the convolution is then computed.

4. Parameters

1: **wavname** – Nag_WavType *Input*
On entry: the wavelet filter name.
Constraint: **wavname** = Nag_Morlet.

2: **wavparam** – Integer *Input*
On entry: the non-dimensional wave number for the Morlet wavelet or the order of the derivative for the Gaussian wavelet.
It is not referenced when **wavname** = Nag_MexHat.
Constraint: $5 \leq \mathbf{wavparam} \leq 20$ when **wavname** = Nag_Morlet;
 $1 \leq \mathbf{wavparam} \leq 8$ when **wavname** = Nag_DGauss.

3: **n** – Integer *Input*
On entry: the number of data values in **x**.
Constraint: $\mathbf{n} \geq 2$, the largest prime factor of **n** must not exceed 19 and the total number of prime factors of **n**, counting repetitions, must not exceed 20.

4: **x[n]** – double *Input*
On entry: the data array.

5: **ns** – Integer *Input*
On entry: the number of scales to be computed.

Constraint: $\mathbf{ns} \geq 1$.

6: **scales**[**ns**] – Integer

Input

On entry: the scales at which the transform is to be computed.

Constraint: **scales**[*i*] ≥ 1 .

7: **coefs**[**ns**×**n**] – double

Output

On exit: the transform coefficients at the requested scales. The coefficient at scale *i* and position *j* is given by **coefs**[*i* × **n** + *j*] for $i = 0, 1, \dots, \mathbf{ns} - 1$ and $j = 0, 1, \dots, \mathbf{n} - 1$.

8: **fail** — NagError *

Output

The NAG error parameter (see the Essential Introduction).

5. Error Indicators and Warnings

NE_BAD_PARAM

On entry, parameter *<value>* had an illegal value.

NE_INT

On entry, **n** = *<value>*.

Constraint: **n** ≥ 2 .

On entry, **ns** = *<value>*.

Constraint: **ns** ≥ 1 .

6. Example

6.1 Program Text

```
/* cwt_ex.c
 *
 * Copyright 2006 Numerical Algorithms Group
 *
 * Test 1D Real CWT
 *
 */

#include <stdio.h>
#include <string.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nag_wav.h>

int main(void)
{
    char wavelet[20];
    Integer exit_status;
    Integer i, j, n, ns, wavparam;
    Integer *scales=0;
    double *x=0, *coefs=0;
```

```

Nag_WavType wavname;
NagError fail;

INIT_FAIL(fail);
exit_status = 0;

/* Read/initialise input data x[0:n-1] */
/* Skip heading in data file */
printf("nag_cwt_real Example Program Results\n");

Vscanf("%*[^\\n] ");
/* Read wavelet type */
Vscanf("%s%*[^\\n]", wavelet);

if (!strcmp("Morlet", wavelet))
    wavname = Nag_Morlet;
else if (!strcmp("DOG", wavelet))
    wavname = Nag_DGauss;
else if (!strcmp("MexHat", wavelet))
    wavname = Nag_MexHat;
else
    {
        Vprintf("wavelet type not recognised\n");
        exit_status = -3;
        goto END;
    }
Vscanf("%ld%*[^\\n]", &wavparam);

Vscanf("%ld%*[^\\n] ", &n);
Vscanf("%ld%*[^\\n] ", &ns);

if (n <= 0)
    goto END;

/* Allocate arrays */
if ( !(scales = NAG_ALLOC(ns, Integer)) ||
    !(coefs = NAG_ALLOC(n*ns, double)) ||
    !(x = NAG_ALLOC(n, double)) )
    {
        Vprintf("Allocation failure\n");
        exit_status = -1;
        goto END;
    }

for (i = 0; i < ns; i++)
    {
        Vscanf("%ld", &scales[i]);
        Vscanf("%*[^\\n] ");
    }

for (i = 0; i < n; i++)
    {

```

```

        Vscanf("%lf", &x[i]);
        Vscanf("%*[^\\n] ");
    }

/* 1D Continuous Wavelet Transform (CWT) */
nag_cwt_real(wavname, wavparam, n, x, ns, scales, coefs, &fail);
if (fail.code != NE_NOERROR)
    {
        Vprintf("Error from nag_cwt_real.\\n%s\\n", fail.message);
        exit_status = 1;
        goto END;
    }

/* Transform result */
printf("Transform coefficients\\n\\n");
for (i = 0; i < ns; i++)
    for (j = 0; j < n; j++)
        Vprintf("%12.4e%s", coefs[i*n+j], (j%6==5 || j==n-1) ? "\\n" : " ");

    END:

if (x) NAG_FREE(x);
if (scales) NAG_FREE(scales);
if (coefs) NAG_FREE(coefs);

return exit_status;
}

```

6.2 Program Data

```

/* Wavelet nag_cwt_real test data */
Morlet      /* wavelet */
5           /* wavparam */
32          /* n = length(x) */
32          /* ns = length(scales) */
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

```

```
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32          /* scales[i], i = 0:ns-1 */
0.0
0.0
0.0
5.9398E-4
5.9398E-4
0.0
0.0
0.0
0.0
5.9398E-4
5.9398E-4
5.9398E-4
5.9398E-4
0.00119
0.00119
0.00178
0.00178
0.00119
0.00119
5.9398E-4
5.9398E-4
5.9398E-4
5.9398E-4
0.0
0.0
0.0
0.0
5.9398E-4
5.9398E-4
0.0
0.0
0.0          /* x[i], i = 0:n-1 */
```

6.3 Program Results

nag_cwt_real Example Program Results
Transform coefficients

-1.0818e-06	2.6957e-06	7.4215e-05	-2.6900e-06	-1.4628e-04	-2.7096e-06
7.3128e-05	5.3718e-06	7.2040e-05	-3.6290e-08	-7.4229e-05	-4.6273e-09
7.3397e-05	2.6998e-06	3.3815e-07	-5.3379e-06	-1.4311e-04	-5.3379e-06
3.4370e-07	2.6998e-06	7.3397e-05	9.2131e-10	-7.4218e-05	-2.5174e-08
7.2057e-05	5.3885e-06	7.3139e-05	-2.6984e-06	-1.4627e-04	-2.6845e-06
7.4220e-05	2.7012e-06				
-4.5931e-05	9.9598e-05	-6.2189e-05	-1.0497e-04	2.1324e-04	-9.9657e-05
-1.0462e-04	2.0151e-04	-1.4704e-04	7.6472e-06	6.8679e-05	4.1594e-06
-1.0841e-04	9.6692e-05	3.6280e-05	-2.0877e-04	2.9300e-04	-2.0877e-04
3.6280e-05	9.6692e-05	-1.0840e-04	4.1673e-06	6.8679e-05	7.6472e-06
-1.4704e-04	2.0151e-04	-1.0461e-04	-9.9649e-05	2.1325e-04	-1.0496e-04
-6.2174e-05	9.9614e-05				
1.7366e-04	1.8048e-05	-3.1754e-04	-7.7344e-06	3.5627e-04	-2.0750e-05
-1.9304e-04	3.5136e-05	-6.2944e-05	-1.2724e-05	2.1038e-04	-4.2011e-06
-1.5477e-04	2.0125e-05	-2.6063e-05	-2.1096e-05	1.2556e-04	-2.1426e-05
-2.6063e-05	1.9794e-05	-1.5477e-04	-4.2022e-06	2.1038e-04	-1.3053e-05
-6.2944e-05	3.5465e-05	-1.9304e-04	-2.0418e-05	3.5628e-04	-7.7248e-06
-3.1754e-04	1.8379e-05				
6.5828e-05	-2.9099e-04	-3.4968e-04	9.0738e-05	4.9359e-04	3.0664e-04
-2.4650e-04	-5.0050e-04	-2.0020e-04	2.8281e-04	4.3492e-04	1.3577e-04
-2.7052e-04	-3.8270e-04	-1.3780e-04	2.0858e-04	3.6336e-04	2.0858e-04
-1.3780e-04	-3.8270e-04	-2.7052e-04	1.3577e-04	4.3492e-04	2.8281e-04
-2.0020e-04	-5.0050e-04	-2.4650e-04	3.0664e-04	4.9359e-04	9.0738e-05
-3.4968e-04	-2.9099e-04				
-2.7054e-04	-4.2393e-04	-1.7694e-04	3.2375e-04	5.9747e-04	2.8656e-04
-3.2563e-04	-6.2285e-04	-3.1644e-04	3.1688e-04	6.0500e-04	2.5297e-04
-3.7339e-04	-6.3398e-04	-2.7445e-04	3.6617e-04	7.0833e-04	3.6617e-04
-2.7445e-04	-6.3398e-04	-3.7339e-04	2.5297e-04	6.0500e-04	3.1688e-04
-3.1644e-04	-6.2285e-04	-3.2563e-04	2.8656e-04	5.9747e-04	3.2375e-04
-1.7694e-04	-4.2393e-04				
-3.7809e-04	-2.8689e-04	4.0690e-05	3.8839e-04	4.6258e-04	2.0582e-04
-1.8637e-04	-3.5896e-04	-2.1206e-04	9.3106e-05	2.1351e-04	3.1593e-05
-2.5840e-04	-3.5302e-04	-8.1089e-05	3.0064e-04	5.1050e-04	3.0064e-04
-8.1089e-05	-3.5348e-04	-2.5840e-04	3.2061e-05	2.1351e-04	9.3106e-05
-2.1206e-04	-3.5943e-04	-1.8637e-04	2.0582e-04	4.6258e-04	3.8792e-04
4.0690e-05	-2.8735e-04				
-3.3598e-04	-1.6568e-04	1.1821e-04	3.4574e-04	4.2070e-04	3.2342e-04
1.0629e-04	-1.1200e-04	-2.3743e-04	-2.6608e-04	-2.8530e-04	-2.5917e-04
-1.9989e-04	-6.7075e-05	1.5942e-04	3.4540e-04	4.3860e-04	3.4540e-04
1.5942e-04	-6.7075e-05	-1.9989e-04	-2.5917e-04	-2.8530e-04	-2.6608e-04
-2.3743e-04	-1.1200e-04	1.0629e-04	3.2342e-04	4.2070e-04	3.4574e-04
1.1821e-04	-1.6568e-04				
-2.8067e-04	-7.3383e-05	1.9722e-04	4.3272e-04	5.4200e-04	4.7807e-04
2.5506e-04	-5.9904e-05	-3.7281e-04	-5.9366e-04	-6.6096e-04	-5.5500e-04
-3.0050e-04	3.9657e-05	3.7870e-04	6.2742e-04	7.1866e-04	6.2742e-04
3.7870e-04	3.9657e-05	-3.0050e-04	-5.5500e-04	-6.6096e-04	-5.9366e-04
-3.7281e-04	-5.9904e-05	2.5506e-04	4.7807e-04	5.4200e-04	4.3272e-04
1.9722e-04	-7.3383e-05				
-1.6272e-04	1.2124e-04	4.0229e-04	6.1102e-04	6.6759e-04	5.1948e-04
2.2189e-04	-1.7510e-04	-5.9151e-04	-8.8881e-04	-9.3654e-04	-7.8432e-04
-4.0537e-04	1.0566e-04	5.6627e-04	9.3537e-04	1.0605e-03	9.3537e-04

5.6627e-04	1.0566e-04	-4.0537e-04	-7.8432e-04	-9.3654e-04	-8.8881e-04
-5.9151e-04	-1.7510e-04	2.2189e-04	5.1891e-04	6.6759e-04	6.1159e-04
4.0229e-04	1.2124e-04				
9.5737e-05	3.5382e-04	6.2511e-04	7.1374e-04	6.4450e-04	4.2183e-04
2.2599e-05	-4.6215e-04	-8.4089e-04	-1.0767e-03	-1.1140e-03	-8.2629e-04
-3.6673e-04	2.0249e-04	7.6523e-04	1.1847e-03	1.2867e-03	1.1847e-03
7.6523e-04	2.0249e-04	-3.6673e-04	-8.2629e-04	-1.1140e-03	-1.0767e-03
-8.4089e-04	-4.6215e-04	2.2599e-05	4.2183e-04	6.4450e-04	7.1374e-04
6.2511e-04	3.5382e-04				
3.7462e-04	5.9965e-04	7.0310e-04	6.8334e-04	4.9385e-04	1.4865e-04
-2.9240e-04	-7.2580e-04	-1.0516e-03	-1.2138e-03	-1.0963e-03	-7.6174e-04
-2.4237e-04	3.4059e-04	8.9447e-04	1.2872e-03	1.4308e-03	1.3080e-03
8.9447e-04	3.6141e-04	-2.4237e-04	-7.6167e-04	-1.0963e-03	-1.1931e-03
-1.0516e-03	-7.4648e-04	-2.9240e-04	1.2801e-04	4.9385e-04	6.8309e-04
7.0310e-04	5.7883e-04				
5.8233e-04	6.7349e-04	6.6002e-04	4.8761e-04	1.7271e-04	-1.8470e-04
-6.0928e-04	-9.5851e-04	-1.1709e-03	-1.1946e-03	-9.8630e-04	-6.2057e-04
-7.4703e-05	4.8904e-04	9.8691e-04	1.3506e-03	1.4597e-03	1.3506e-03
9.8691e-04	4.8904e-04	-7.4703e-05	-6.2057e-04	-9.8630e-04	-1.1946e-03
-1.1709e-03	-9.5851e-04	-6.0928e-04	-1.8470e-04	1.7271e-04	4.8761e-04
6.6002e-04	6.7349e-04				
6.2714e-04	5.9737e-04	4.4335e-04	1.9878e-04	-1.5546e-04	-5.2988e-04
-8.7536e-04	-1.0988e-03	-1.1954e-03	-1.0966e-03	-8.0788e-04	-4.0073e-04
9.0956e-05	5.9564e-04	1.0560e-03	1.3670e-03	1.5007e-03	1.3670e-03
1.0560e-03	5.9564e-04	9.0956e-05	-4.0073e-04	-8.0788e-04	-1.0966e-03
-1.1954e-03	-1.0988e-03	-8.7536e-04	-5.2988e-04	-1.5546e-04	1.9878e-04
4.4335e-04	5.9737e-04				
5.4544e-04	4.1424e-04	1.5948e-04	-1.4830e-04	-4.4534e-04	-7.7831e-04
-1.0399e-03	-1.1605e-03	-1.1563e-03	-9.9555e-04	-6.5179e-04	-2.6669e-04
2.3435e-04	7.1610e-04	1.1199e-03	1.3640e-03	1.4910e-03	1.3640e-03
1.1199e-03	7.1610e-04	2.3435e-04	-2.6669e-04	-6.5179e-04	-9.9555e-04
-1.1563e-03	-1.1605e-03	-1.0399e-03	-7.7831e-04	-4.4534e-04	-1.4830e-04
1.5948e-04	4.1424e-04				
3.3013e-04	1.1962e-04	-1.3284e-04	-4.3327e-04	-7.6877e-04	-9.5653e-04
-1.1426e-03	-1.1948e-03	-1.0439e-03	-8.4924e-04	-4.9012e-04	-5.4367e-05
3.9010e-04	7.5891e-04	1.1531e-03	1.4152e-03	1.4583e-03	1.4152e-03
1.1531e-03	7.5891e-04	3.9010e-04	-5.4367e-05	-4.9012e-04	-8.4924e-04
-1.0439e-03	-1.1948e-03	-1.1426e-03	-9.5653e-04	-7.6877e-04	-4.3327e-04
-1.3284e-04	1.1962e-04				
1.0951e-04	-1.5339e-04	-4.3738e-04	-7.1276e-04	-9.4729e-04	-1.1101e-03
-1.1759e-03	-1.1284e-03	-9.6339e-04	-6.9030e-04	-3.3157e-04	7.9081e-05
5.0031e-04	8.8790e-04	1.2000e-03	1.4023e-03	1.4724e-03	1.4023e-03
1.2000e-03	8.8790e-04	5.0031e-04	7.9081e-05	-3.3157e-04	-6.9030e-04
-9.6339e-04	-1.1284e-03	-1.1759e-03	-1.1101e-03	-9.4729e-04	-7.1276e-04
-4.3738e-04	-1.5339e-04				
-1.5428e-04	-4.4302e-04	-7.2413e-04	-9.0561e-04	-1.0995e-03	-1.1635e-03
-1.1690e-03	-1.0914e-03	-8.3630e-04	-5.6737e-04	-1.6990e-04	2.2970e-04
6.0835e-04	9.2640e-04	1.2606e-03	1.4646e-03	1.4779e-03	1.4646e-03
1.2606e-03	9.2640e-04	6.0835e-04	2.2970e-04	-1.6990e-04	-5.6737e-04
-8.3630e-04	-1.0914e-03	-1.1690e-03	-1.1635e-03	-1.0995e-03	-9.0561e-04
-7.2413e-04	-4.4302e-04				
-4.4603e-04	-6.7636e-04	-9.1380e-04	-1.0708e-03	-1.1621e-03	-1.2267e-03

-1.1533e-03	-1.0161e-03	-7.3478e-04	-4.1582e-04	-4.3977e-05	3.5274e-04
6.9558e-04	1.0046e-03	1.3130e-03	1.4717e-03	1.5717e-03	1.4717e-03
1.3130e-03	1.0046e-03	6.9558e-04	3.5274e-04	-4.3977e-05	-4.1582e-04
-7.3478e-04	-1.0161e-03	-1.1533e-03	-1.2267e-03	-1.1621e-03	-1.0708e-03
-9.1380e-04	-6.7636e-04				
-6.8157e-04	-9.2506e-04	-1.0339e-03	-1.2063e-03	-1.2782e-03	-1.1612e-03
-1.0985e-03	-9.1109e-04	-5.6695e-04	-2.7519e-04	5.7800e-05	4.7662e-04
8.2234e-04	1.0603e-03	1.3695e-03	1.5223e-03	1.4920e-03	1.5223e-03
1.3695e-03	1.0603e-03	8.2234e-04	4.7662e-04	5.7800e-05	-2.7519e-04
-5.6695e-04	-9.1109e-04	-1.0985e-03	-1.1612e-03	-1.2782e-03	-1.2063e-03
-1.0339e-03	-9.2506e-04				
-8.4968e-04	-1.0440e-03	-1.1812e-03	-1.3104e-03	-1.3080e-03	-1.1832e-03
-1.0062e-03	-7.3866e-04	-5.0400e-04	-1.7896e-04	1.6180e-04	5.4867e-04
9.0826e-04	1.2197e-03	1.4330e-03	1.5023e-03	1.5610e-03	1.5023e-03
1.4330e-03	1.2197e-03	9.0826e-04	5.4867e-04	1.6180e-04	-1.7896e-04
-5.0400e-04	-7.3866e-04	-1.0062e-03	-1.1832e-03	-1.3080e-03	-1.3104e-03
-1.1812e-03	-1.0440e-03				
-1.0440e-03	-1.1892e-03	-1.3115e-03	-1.3326e-03	-1.3139e-03	-1.1858e-03
-9.5465e-04	-6.9703e-04	-3.5868e-04	-2.4711e-05	3.2130e-04	6.5968e-04
1.0029e-03	1.2636e-03	1.4607e-03	1.5476e-03	1.5536e-03	1.5476e-03
1.4607e-03	1.2636e-03	1.0029e-03	6.5968e-04	3.2130e-04	-2.4711e-05
-3.5868e-04	-6.9703e-04	-9.5465e-04	-1.1858e-03	-1.3139e-03	-1.3326e-03
-1.3115e-03	-1.1892e-03				
-1.1598e-03	-1.3105e-03	-1.3519e-03	-1.3310e-03	-1.2501e-03	-1.0876e-03
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