NAG Toolbox

nag_sum_convcorr_real_nowork (c06ek)

1 Purpose

nag_sum_convcorr_real_nowork (c06ek) calculates the circular convolution or correlation of two real vectors of period n. (No extra workspace is required.)

Note: This function is scheduled to be withdrawn, please see c06ek in Advice on Replacement Calls for Withdrawn/Superseded Routines..

2 Syntax

```
[x, y, ifail] = nag_sum_convcorr_real_nowork(job, x, y, 'n', n)
[x, y, ifail] = c06ek(job, x, y, 'n', n)
```

3 Description

nag_sum_convcorr_real_nowork (c06ek) computes:

if **job** $= 1$, the discrete **convolution** of x and y, defined by

$$z_k = \sum_{j=0}^{n-1} x_j y_{k-j} = \sum_{j=0}^{n-1} x_{k-j} y_j;$$

if **job** $= 2$, the discrete **correlation** of x and y defined by

$$w_k = \sum_{j=0}^{n-1} x_j y_{k+j}.$$

Here x and y are real vectors, assumed to be periodic, with period n, i.e., $x_j = x_{j\pm n} = x_{j\pm 2n} = \ldots$; z and w are then also periodic with period n.

Note: this usage of the terms 'convolution' and 'correlation' is taken from Brigham (1974). The term 'convolution' is sometimes used to denote both these computations.

If $\hat{x}$, $\hat{y}$, $\hat{z}$ and $\hat{w}$ are the discrete Fourier transforms of these sequences, i.e.,

$$\hat{x}_k = \frac{1}{\sqrt{n}} \sum_{j=0}^{n-1} x_j \times \exp\left(-i\frac{2\pi jk}{n}\right), \text{ etc.},$$

then $\hat{z}_k = \sqrt{n}.\hat{x}_k\hat{y}_k$ and $\hat{w}_k = \sqrt{n}.\bar{\hat{x}}_k\hat{y}_k$ (the bar denoting complex conjugate).

This function calls the same auxiliary functions as nag_sum_fft_real_1d_nowork (c06ea) and nag_sum_fft_hermitian_1d_nowork (c06eb) to compute discrete Fourier transforms, and there are some restrictions on the value of n.

4 References

Brigham E O (1974) *The Fast Fourier Transform* Prentice–Hall

5 Parameters

5.1 Compulsory Input Parameters

1: **job** – INTEGER

The computation to be performed.

job $= 1$

$$z_k = \sum_{j=0}^{n-1} x_j y_{k-j} \text{ (convolution);}$$

job $= 2$

$$w_k = \sum_{j=0}^{n-1} x_j y_{k+j} \text{ (correlation).}$$

Constraint: **job** $= 1$ or 2.

2: **x**(**n**) – REAL (KIND=nag_wp) array

The elements of one period of the vector x. If **x** is declared with bounds $(0 : \mathbf{n} - 1)$ in the function from which nag_sum_convcorr_real_nowork (c06ek) is called, then **x**(j) must contain x_j, for $j = 0, 1, \ldots, n - 1$.

3: **y**(**n**) – REAL (KIND=nag_wp) array

The elements of one period of the vector y. If **y** is declared with bounds $(0 : \mathbf{n} - 1)$ in the function from which nag_sum_convcorr_real_nowork (c06ek) is called, then **y**(j) must contain y_j, for $j = 0, 1, \ldots, n - 1$.

5.2 Optional Input Parameters

1: **n** – INTEGER

Default: the dimension of the arrays **x**, **y**. (An error is raised if these dimensions are not equal.)

n, the number of values in one period of the vectors **x** and **y**.

Constraint: **n** > 1.

5.3 Output Parameters

1: **x**(**n**) – REAL (KIND=nag_wp) array

The corresponding elements of the discrete convolution or correlation.

2: **y**(**n**) – REAL (KIND=nag_wp) array

The discrete Fourier transform of the convolution or correlation returned in the array **x**; the transform is stored in Hermitian form. If the components of the transform are:

$$\left.\begin{array}{l} \hat{Z}_k = a_k + ib_k \\ \hat{Z}_{n-k} = a_k - ib_k \end{array}\right\} \quad k = 0, 1, \ldots n/2$$

where b_0 and $b_{n/2}$ when n is even then **x**$(k + 1)$ holds a_k and **x**$(n - k + 1)$ holds nonzero b_k (see Section 2.1.2 in the C06 Chapter Introduction).

3: **ifail** – INTEGER

ifail $= 0$ unless the function detects an error (see Section 5).

6 Error Indicators and Warnings

Errors or warnings detected by the function:

ifail $= 1$

At least one of the prime factors of **n** is greater than 19.

ifail $= 2$

n has more than 20 prime factors.

ifail $= 3$

On entry, **n** ≤ 1.

ifail $= 4$

On entry, **job** $\neq 1$ or 2.

ifail $= -99$

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

ifail $= -399$

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

ifail $= -999$

Dynamic memory allocation failed.

7 Accuracy

The results should be accurate to within a small multiple of the ***machine precision***.

8 Further Comments

The time taken is approximately proportional to $n \times \log(n)$, but also depends on the factorization of n. nag_sum_convcorr_real_nowork (c06ek) is faster if the only prime factors of n are 2, 3 or 5; and fastest of all if n is a power of 2.

On the other hand, nag_sum_convcorr_real_nowork (c06ek) is particularly slow if n has several unpaired prime factors, i.e., if the 'square-free' part of n has several factors. For such values of n, nag_sum_convcorr_real (c06fk) (which requires additional double workspace) is considerably faster.

9 Example

This example reads in the elements of one period of two real vectors x and y, and prints their discrete convolution and correlation (as computed by nag_sum_convcorr_real_nowork (c06ek)). In realistic computations the number of data values would be much larger.

9.1 Program Text

```
function c06ek_example

fprintf('c06ek example results\n\n');

x = [1;    1;    1;    1;    1;    0;    0;    0;    0];
y = [0.5;  0.5;  0.5;  0.5;  0;    0;    0;    0;    0];

job = nag_int(1);
[conv, tconv, ifail] = c06ek(job, x, y);
```

```
job = nag_int(2);
[corr, tcorr, ifail] = c06ek(job, x, y);

result = [conv corr];
disp('Convolution  Correlation');
disp(result);
```

9.2 Program Results

```
     c06ek example results

Convolution  Correlation
    0.5000    2.0000
    1.0000    1.5000
    1.5000    1.0000
    2.0000    0.5000
    2.0000    0.0000
    1.5000    0.5000
    1.0000    1.0000
    0.5000    1.5000
    0.0000    2.0000
```