nag_monotonic_intg (e01bhc)

1. Purpose

nag_monotonic_intg (e01bhc) evaluates the definite integral of a piecewise cubic Hermite interpolant over the interval $[a, b]$.

2. Specification

```
#include <nag.h>
#include <nage01.h>

void nag_monotonic_intg(Integer n, double x[], double f[], double d[],
            double a, double b, double *integral, NagError *fail)
```

3. Description

This function evaluates the definite integral of a piecewise cubic Hermite interpolant, as computed by nag_monotonic_interpolant (e01bec), over the interval $[a, b]$.

If either a or b lies outside the interval from $\mathbf{x}[0]$ to $\mathbf{x}[n-1]$, computation of the integral involves extrapolation and a warning is returned.

The function is derived from routine PCHIA in Fritsch (1982).

4. Parameters

n
x[n]
f[n]
d[n]
: Input: **n**, **x**, **f** and **d** must be unchanged from the previous call of nag_monotonic_interpolant (e01bec).

a
b
: Input: the interval $[a, b]$ over which integration is to be performed.

integral
: Output: the value of the definite integral of the interpolant over the interval $[a, b]$.

fail
: The NAG error parameter, see the Essential Introduction to the NAG C Library.

5. Error Indications and Warnings

NE_INT_ARG_LT
: On entry, **n** must not be less than 2: $\mathbf{n} = \langle value \rangle$.

NE_NOT_MONOTONIC
: On entry, $\mathbf{x}[r-1] \geq \mathbf{x}[r]$ for $r = \langle value \rangle$: $\mathbf{x}[r-1] = \langle value \rangle$, $\mathbf{x}[r] = \langle value \rangle$.
The values of $\mathbf{x}[r]$, for $r = 0, 1, \ldots, n-1$ are not in strictly increasing order.

NW_INTERVAL_EXTRAPOLATE
: On entry, limits **a**, **b** must not be outside interval [$\mathbf{x}[0]$, $\mathbf{x}[n-1]$], $\mathbf{a} = \langle value \rangle$, $\mathbf{b} = \langle value \rangle$, $\mathbf{x}[0] = \langle value \rangle$, $\mathbf{x}[\langle value \rangle] = \langle value \rangle$. Extrapolation was performed to compute the integral. The value returned is therefore unreliable.

6. Further Comments

The time taken by the function is approximately proportional to the number of data points included within the interval $[a, b]$.

6.1. Accuracy

The computational error in the value returned for **integral** should be negligible in most practical situations.

6.2. References

Fritsch F N (August 1982) *PCHIP Final Specifications* Lawrence Livermore National Laboratory report UCID-30194.

7. See Also

nag_monotonic_interpolant (e01bec)

8. Example

This example program reads in values of **n**, **x**, **f** and **d**. It then reads in pairs of values for **a** and **b**, and evaluates the definite integral of the interpolant over the interval [**a**, **b**] until end-of-file is reached.

8.1. Program Text

```
/* nag_monotonic_intg(e01bhc) Example Program
 *
 * Copyright 1991 Numerical Algorithms Group.
 *
 * Mark 2, 1991.
 */

#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nage01.h>

#define NMAX 50

main()
{
  double a, b, integral, d[NMAX], f[NMAX], x[NMAX];
  Integer n, r;

  Vprintf("e01bhc Example Program Results\n");
  Vscanf("%*[^\n]");  /* Skip heading in data file */
  Vscanf("%ld",&n);
  if (n>0 && n<=NMAX)
    {
      for (r=0; r<n; r++)
        Vscanf("%lf%lf%lf",&x[r], &f[r], &d[r]);
      Vprintf("                                          Integral\n");
      Vprintf("          a                   b           over (a,b)\n");
      /* Read a, b pairs until end of file and compute
       * definite integrals.
       */
      while(scanf("%lf%lf",&a,&b) !=EOF)
        {
          e01bhc(n, x, f, d, a, b, &integral, NAGERR_DEFAULT);
          Vprintf("%13.4f      %13.4f      %13.4f\n",a,b,integral);
        }
      exit(EXIT_SUCCESS);
    }
  else
    {
      Vfprintf(stderr,"n is out of range : n = %ld\n",n);
      exit(EXIT_FAILURE);
    }
}
```

8.2. Program Data

```
e01bhc Example Program Data
   9
   7.990  0.00000E+0  0.00000E+0
   8.090  0.27643E-4  5.52510E-4
   8.190  0.43749E-1  0.33587E+0
   8.700  0.16918E+0  0.34944E+0
   9.200  0.46943E+0  0.59696E+0
   10.00  0.94374E+0  6.03260E-2
   12.00  0.99864E+0  8.98335E-4
   15.00  0.99992E+0  2.93954E-5
   20.00  0.99999E+0  0.00000E+0
   7.99       20.0
   10.0       12.0
   12.0       10.0
   15.0       15.0
```

8.3. Program Results

```
e01bhc Example Program Results
                                        Integral
          a                 b           over (a,b)
       7.9900           20.0000            10.7648
      10.0000           12.0000             1.9622
      12.0000           10.0000            -1.9622
      15.0000           15.0000             0.0000
```