NAG Library Function Document

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, const double x[], const double f[],
     const double d[], double a, double b, double *integral, NagError *fail)
```

3 Description

nag_monotonic_intg (e01bhc) 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 References

Fritsch F N (1982) PCHIP final specifications *Report UCID-30194* Lawrence Livermore National Laboratory

5 Arguments

1: **n** – Integer *Input*

On entry: **n** must be unchanged from the previous call of nag_monotonic_interpolant (e01bec).

2: **x**[**n**] – const double *Input*
3: **f**[**n**] – const double *Input*
4: **d**[**n**] – const double *Input*

On entry: **x**, **f** and **d** must be unchanged from the previous call of nag_monotonic_interpolant (e01bec).

5: **a** – double *Input*
6: **b** – double *Input*

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

7: **integral** – double * *Output*

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

8: **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_INT_ARG_LT

On entry, $\mathbf{n} = \langle value \rangle$.
Constraint: $\mathbf{n} \geq 2$.

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.

7 Accuracy

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

8 Parallelism and Performance

nag_monotonic_intg (e01bhc) is not threaded in any implementation.

9 Further Comments

The time taken by nag_monotonic_intg (e01bhc) is approximately proportional to the number of data points included within the interval $[a, b]$.

10 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 $(\mathbf{a}, \mathbf{b})$ until end-of-file is reached.

10.1 Program Text

```
/* nag_monotonic_intg (e01bhc) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */

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

int main(void)
{
  Integer exit_status = 0, n, r;
  NagError fail;
  double a, b, *d = 0, *f = 0, integral, *x = 0;

  INIT_FAIL(fail);

  printf("nag_monotonic_intg (e01bhc) Example Program Results\n");
#ifdef _WIN32
```

```
  scanf_s("%*[^\n]"); /* Skip heading in data file */
#else
  scanf("%*[^\n]"); /* Skip heading in data file */
#endif
#ifdef _WIN32
  scanf_s("%" NAG_IFMT "", &n);
#else
  scanf("%" NAG_IFMT "", &n);
#endif
  if (n >= 2) {
    if (!(d = NAG_ALLOC(n, double)) ||
        !(f = NAG_ALLOC(n, double)) || !(x = NAG_ALLOC(n, double)))
    {
      printf("Allocation failure\n");
      exit_status = -1;
      goto END;
    }
  }
  else {
    printf("Invalid n.\n");
    exit_status = 1;
    return exit_status;
  }
  for (r = 0; r < n; r++)
#ifdef _WIN32
    scanf_s("%lf%lf%lf", &x[r], &f[r], &d[r]);
#else
    scanf("%lf%lf%lf", &x[r], &f[r], &d[r]);
#endif
  printf("                                              Integral\n");
  printf("          a                   b               over (a,b)\n");
  /* Read a, b pairs until end of file and compute
   * definite integrals.
   */
#ifdef _WIN32
  while (scanf_s("%lf%lf", &a, &b) != EOF)
#else
  while (scanf("%lf%lf", &a, &b) != EOF)
#endif
  {
    /* nag_monotonic_intg (e01bhc).
     * Evaluation of interpolant computed by
     * nag_monotonic_interpolant (e01bec), definite integral
     */
    nag_monotonic_intg(n, x, f, d, a, b, &integral, &fail);
    if (fail.code != NE_NOERROR) {
      printf("Error from nag_monotonic_intg (e01bhc).\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }
    printf("%13.4f      %13.4f      %13.4f\n", a, b, integral);
  }
END:
  NAG_FREE(d);
  NAG_FREE(f);
  NAG_FREE(x);
  return exit_status;
}
```

10.2 Program Data

```
nag_monotonic_intg (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
```

10.3 Program Results

```
nag_monotonic_intg (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
```