NAG Library Function Document

nag_monotonic_deriv (e01bgc)

1 Purpose

nag_monotonic_deriv (e01bgc) evaluates a piecewise cubic Hermite interpolant and its first derivative at a set of points.

2 Specification

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

```
void nag_monotonic_deriv (Integer n, const double x[], const double f[],
     const double d[], Integer m, const double px[], double pf[],
     double pd[], NagError *fail)
```

3 Description

nag_monotonic_deriv (e01bgc) evaluates a piecewise cubic Hermite interpolant, as computed by the NAG function nag_monotonic_interpolant (e01bec), at the points $\mathbf{px}[i]$, for $i = 0, 1, \ldots, m-1$. The first derivatives at the points are also computed. If any point lies outside the interval from $\mathbf{x}[0]$ to $\mathbf{x}[n-1]$, values of the interpolant and its derivative are extrapolated from the nearest extreme cubic, and a warning is returned.

If values of the interpolant only, and not of its derivative, are required, nag_monotonic_evaluate (e01bfc) should be used.

The function is derived from routine PCHFD 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: **m** – Integer *Input*

On entry: m, the number of points at which the interpolant is to be evaluated.

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

6: **px**[**m**] – const double *Input*

On entry: the m values of x at which the interpolant is to be evaluated.

7: **pf**[**m**] – double *Output*

On exit: **pf**$[i]$ contains the value of the interpolant evaluated at the point **px**$[i]$, for $i = 0, 1, \ldots, m - 1$.

8: **pd**[**m**] – double *Output*

On exit: **pd**$[i]$ contains the first derivative of the interpolant evaluated at the point **px**$[i]$, for $i = 0, 1, \ldots, m - 1$.

9: **fail** – NagError * *Input/Output*

The NAG error argument (see Section 3.6 in the Essential Introduction).

6 Error Indicators and Warnings

NE_INT_ARG_LT

On entry, **m** $= \langle value \rangle$.
Constraint: **m** ≥ 1.

On entry, **n** $= \langle value \rangle$.
Constraint: **n** ≥ 2.

NE_NOT_MONOTONIC

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

NW_EXTRAPOLATE

Warning – some points in array **px** lie outside the range **x**$[0] \ldots$ **x**$[n-1]$. Values at these points are unreliable as they have been computed by extrapolation.

7 Accuracy

The computational errors in the arrays **pf** and **pd** should be negligible in most practical situations.

8 Parallelism and Performance

Not applicable.

9 Further Comments

The time taken by nag_monotonic_deriv (e01bgc) is approximately proportional to the number of evaluation points, m. The evaluation will be most efficient if the elements of **px** are in nondecreasing order (or, more generally, if they are grouped in increasing order of the intervals [**x**$[r-1]$, **x**$[r]$]). A single call of nag_monotonic_deriv (e01bgc) with $m > 1$ is more efficient than several calls with $m = 1$.

10 Example

This example program reads in values of **n**, **x**, **f** and **d** and calls nag_monotonic_deriv (e01bgc) to compute the values of the interpolant and its derivative at equally spaced points.

10.1 Program Text

```
/* nag_monotonic_deriv (e01bgc) Example Program.
 *
 * Copyright 2014 Numerical Algorithms Group.
 *
 * Mark 2, 1991.
 * Mark 8 revised, 2004.
 */

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

int main(void)
{
  Integer  exit_status = 0, i, m, n, r;
  NagError fail;
  double   *d = 0, *f = 0, *pd = 0, *pf = 0, *px = 0, step, *x = 0;

  INIT_FAIL(fail);

  printf("nag_monotonic_deriv (e01bgc) 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 (!(x = NAG_ALLOC(n, double)) ||
          !(f = NAG_ALLOC(n, double)) ||
          !(d = 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
#ifdef _WIN32
  scanf_s("%"NAG_IFMT"", &m);
#else
  scanf("%"NAG_IFMT"", &m);
#endif
  if (m >= 1)
    {
      if (!(pd = NAG_ALLOC(m, double)) ||
          !(pf = NAG_ALLOC(m, double)) ||
          !(px = NAG_ALLOC(m, double)))
        {
          printf("Allocation failure\n");
          exit_status = -1;
          goto END;
```

```
        }
    }
  else
    {
      printf("Invalid m.\n");
      exit_status = 1;
      return exit_status;
    }
  /* compute m equally spaced points from x[0] to x[n-1]. */
  step = (x[n-1]-x[0]) / (double)(m-1);
  for (i = 0; i < m; i++)
    px[i] = MIN(x[0]+i*step, x[n-1]);
  /* nag_monotonic_deriv (e01bgc).
   * Evaluation of interpolant computed by
   * nag_monotonic_interpolant (e01bec), function and first
   * derivative
   */
  nag_monotonic_deriv(n, x, f, d, m, px, pf, pd, &fail);
  if (fail.code != NE_NOERROR)
    {
      printf("Error from nag_monotonic_deriv (e01bgc).\n%s\n",
              fail.message);
      exit_status = 1;
      goto END;
    }
  printf("                            Interpolated");
  printf("      Interpolated\n");
  printf("       Abscissa               Value");
  printf("           Derivative\n");
  for (i = 0; i < m; i++)
    printf("%15.4f      %15.4f      %15.3e\n", px[i], pf[i], pd[i]);
 END:
  NAG_FREE(x);
  NAG_FREE(pd);
  NAG_FREE(pf);
  NAG_FREE(px);
  NAG_FREE(f);
  NAG_FREE(d);
  return exit_status;
}
```

10.2 Program Data

```
nag_monotonic_deriv (e01bgc) 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
   11
```

10.3 Program Results

```
nag_monotonic_deriv (e01bgc) Example Program Results
                            Interpolated      Interpolated
       Abscissa               Value            Derivative
         7.9900              0.0000             0.000e+00
         9.1910              0.4640             6.060e-01
        10.3920              0.9645             4.569e-02
        11.5930              0.9965             9.917e-03
        12.7940              0.9992             6.249e-04
        13.9950              0.9998             2.708e-04
```

```
      15.1960              0.9999            2.809e-05
      16.3970              1.0000            2.034e-05
      17.5980              1.0000            1.308e-05
      18.7990              1.0000            6.297e-06
      20.0000              1.0000           -9.529e-22
```