

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 $i = 0, 1, \dots, m - 1$. 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: **m** ≥ 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 $i = 0, 1, \dots, m - 1$.
- 8: **pd**[**m**] – double *Output*
On exit: **pd**[*i*] contains the first derivative of the interpolant evaluated at the point **px**[*i*], for $i = 0, 1, \dots, m - 1$.
- 9: **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, **m** = *<value>*.
 Constraint: **m** ≥ 1 .
 On entry, **n** = *<value>*.
 Constraint: **n** ≥ 2 .

NE_NOT_MONOTONIC

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

NW_EXTRAPOLATE

Warning – some points in array **px** lie outside the range $\mathbf{x}[0] \dots \mathbf{x}[n - 1]$. 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

nag_monotonic_deriv (e01bgc) is not threaded in any implementation.

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 $[\mathbf{x}[r - 1], \mathbf{x}[r]]$). 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.
 *
 * 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, 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

Abcissa	Interpolated Value	Interpolated 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
