

**NAME**

CUTEST\_ceh\_threaded – CUTEst tool to evaluate the sparse Lagrangian Hessian matrix in finite element format.

**SYNOPSIS**

CALL CUTEST\_ceh\_threaded( status, n, m, X, Y, ne, lhe\_ptr, HE\_row\_ptr, HE\_val\_ptr, lhe\_row, HE\_row, lhe\_val, HE\_val, byrows, thread )

**DESCRIPTION**

The CUTEST\_ceh\_threaded subroutine evaluates the Hessian matrix of the Lagrangian function  $l(x, y) = f(x) + y^T c(x)$  for the problem decoded into OUTSDIF.d at the point  $(x, y) = (X, Y)$ . This Hessian matrix is stored as a sparse matrix in finite element format

$$H = \sum_{e=1}^{ne} H_e,$$

where each square symmetric element  $H_e$  involves a small subset of the rows of the Hessian matrix.

The problem under consideration consists in minimizing (or maximizing) an objective function  $f(x)$  over all  $x \in R^n$  subject to general equations  $c_i(x) = 0$ , ( $i \in 1, \dots, m_E$ ), general inequalities  $c_i^l(x) \leq c_i(x) \leq c_i^u(x)$ , ( $i \in m_E + 1, \dots, m$ ), and simple bounds  $x^l \leq x \leq x^u$ . The objective function is group-partially separable and all constraint functions are partially separable.

**ARGUMENTS**

The arguments of CUTEST\_ceh\_threaded are as follows

**status** [out] - integer

the output status: 0 for a successful call, 1 for an array allocation/deallocation error, 2 for an array bound error, 3 for an evaluation error, 4 for an out-of-range thread,

**n** [in] - integer

the number of variables for the problem,

**m** [in] - integer

the total number of general constraints,

**X** [in] - real/double precision

an array which gives the current estimate of the solution of the problem,

**Y** [in] - real/double precision

an array which gives the Lagrange multipliers,

**ne** [out] - integer

the number, ne, of "finite-elements" used,

**lhe\_ptr** [in] - integer

the actual declared dimensions of HE\_row\_ptr and HE\_val\_ptr,

**HE\_row\_ptr** [out] - integer

HE\_row\_ptr(i) points to the position in HE\_row of the first row index involved with element number i: the row indices of element number e are stored in HE\_row between the indices HE\_row\_ptr(e) and HE\_row\_ptr(e+1)-1. HE\_row\_ptr(ne+1) points to the first empty location in HE\_row,

**HE\_val\_ptr** [out] - integer

HE\_val\_ptr(i) points to the position in HE\_val of the first nonzero involved with element number i: the values involved in element number e are stored in HE\_val between the indices HE\_val\_ptr(e) and HE\_val\_ptr(e+1)-1. HE\_val\_ptr(ne+1) points to the first empty location in HE\_val,

**lhe\_row** [in] - integer

the actual declared dimension of HE\_row,

**HE\_row** [out] - integer

an array which holds a list of the row indices involved with each element. Those for element e directly precede those for element e+1, e = 1, ..., ne-1. Since the elements are symmetric, HE\_row is

also the list of column indices involved with each element.

**lhe\_val** [in] - integer

the actual declared dimension of HE\_val,

**HE\_val** [out] - real/double precision

an array of the nonzeros in the upper triangle of H<sub>e</sub>, evaluated at X and stored by rows, or by columns. Those for element e directly proceed those for element, e+1, i = 1, ..., ne-1. Element number e contains the values stored between

HE\_val( HE\_val\_ptr(e) ) and HE\_val( HE\_val\_ptr(e+1)-1 )

and involves the rows/columns stored between

HE\_row( HE\_row\_ptr(e) ) and HE\_row( HE\_row\_ptr(e+1)-1 ).

**byrows** [in] - logical

must be set to .TRUE. if the upper triangle of each H<sub>e</sub> is to be stored by rows, and to .FALSE. if it is to be stored by columns,

**thread** [in] - integer

thread chosen for the evaluation; threads are numbered from 1 to the value threads set when calling CUTEst\_csetup\_threaded.

## AUTHORS

I. Bongartz, A.R. Conn, N.I.M. Gould, D. Orban and Ph.L. Toint

## SEE ALSO

*CUTEr (and SifDec): A Constrained and Unconstrained Testing Environment, revisited,*

N.I.M. Gould, D. Orban and Ph.L. Toint,

ACM TOMS, **29**:4, pp.373-394, 2003.

*CUTE: Constrained and Unconstrained Testing Environment*, I. Bongartz, A.R. Conn, N.I.M. Gould and Ph.L. Toint, TOMS, **21**:1, pp.123-160, 1995.

cutest\_uvh\_threaded(3M), sifdecoder(1).

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