Title

minindex( ) — Indices of minimums and maximums

Description

`minindex(`v`,` k`,` i`,` w`)` returns in i and w the indices of the k minimums of v.

`maxindex(`v`,` k`,` i`,` w`)` does the same, except that it returns the indices of the k maximums.

`minindex()` may be called with $k < 0$; it is then equivalent to `maxindex()`.

`maxindex()` may be called with $k < 0$; it is then equivalent to `minindex()`.

Syntax

void `minindex(`*real vector v*`,` *real scalar k*`,` *i*`,` *w*`)`

void `maxindex(`*real vector v*`,` *real scalar k*`,` *i*`,` *w*`)`

Results are returned in i and w.

i will be a *real colvector*.

w will be a $K \times 2$ *real matrix*, $K \leq |k|$.

Remarks and examples

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Remarks are presented under the following headings:

Remarks are cast in terms of `minindex()` but apply equally to `maxindex()`.

Use of functions when v has all unique values

Consider `v` $= (3, 1, 5, 7, 6)$.

1. `minindex(v, 1, i, w)` returns `i` $= 2$, which means that `v[2]` is the minimum value in `v`.
2. `minindex(v, 2, i, w)` returns `i` $= (2, 1)'$, which means that `v[2]` is the minimum value of `v` and that `v[1]` is the second minimum.

...

5. `minindex(v, 5, i, w)` returns `i` $= (2, 1, 3, 5, 4)'$, which means that the ordered values in `v` are `v[2]`, `v[1]`, `v[3]`, `v[5]`, and `v[4]`.

6. `minindex(v, 6, i, w)`, `minindex(v, 7, i, w)`, and so on, return the same as (5), because there are only five minimums in a five-element vector.

When `v` has unique values, the values returned in `w` are irrelevant.

- In (1), `w` will be $(1,1)$.
- In (2), `w` will be $(1,1\backslash 2,1)$.
- ...
- In (5), `w` will be $(1,1\backslash 2,1\backslash 3,1\backslash 4,1\backslash 5,1)$.

The second column of *w* records the number of tied values. Since the values in *v* are unique, the second column of *w* will be ones. If you have a problem where you are uncertain whether the values in *v* are unique, code

```
if (!allof(w[,2], 1)) {
        /* uniqueness assumption false */
}
```

Use of functions when v has repeated (tied) values

Consider `v` $= (3,2,3,2,3,3)$.

1. `minindex(v, 1, i, w)` returns `i` = (2, 4)', which means that there is one minimum value and that it is repeated in two elements of `v`, namely, `v[2]` and `v[4]`.

   Here, `w` will be (1, 2), but you can ignore that. There are two values in `i` corresponding to the same minimum.

   When `k==1`, `rows(i)` equals the number of observations in `v` corresponding to the minimum, as does `w[1,2]`.

2. `minindex(v, 2, i, w)` returns `i` $= (2,4,1,3,5,6)'$ and `w` $= (1,2\backslash 3,4)$.

   Begin with `w`. The first row of `w` is $(1,2)$, which states that the indices of the first minimums of `v` start at `i[1]` and consist of two elements. Thus the indices of the first minimums are `i[1]` and `i[2]` (the minimums are `v[i[1]]` and `v[i[2]]`, which of course are equal).

   The second row of `w` is $(3,4)$, which states that the indices of the second minimums of `v` start at `i[3]` and consist of four elements: `i[3]`, `i[4]`, `i[5]`, and `i[6]` (which are 1, 3, 5, and 6).

   In summary, `rows(w)` records the number of minimums returned. `w[m,1]` records where in `i` the `m`th minimum begins (it begins at `i[w[m,1]]`). `w[m,2]` records the total number of tied values. Thus one could step across the minimums and the tied values by coding

```
minindex(v, k, i, w)
for (m=1; m<=rows(w); m++) {
        for (j=w[m,1]; j<w[m,1]+w[m,2]; j++) {
              /* i[j] is the index in v of an mth minimum */
        }
}
```

3. `minindex(v, 3, i, w)`, `minindex(v, 4, i, w)`, and so on, return the same as (2) because, with `v` = (3, 2, 3, 2, 3, 3), there are only two minimums.

Summary

Consider `minindex(`v`, `k`, `i`, `w`)`. Returned will be

$$w = \begin{bmatrix} i1 & n1 \\ i2 & n2 \\ . & . \\ . & . \end{bmatrix} \qquad w: K \times 2, \quad K \leq |k|$$

$$i = \begin{bmatrix} j1 \\ j2 \\ j3 \\ j4 \\ . \\ . \\ . \end{bmatrix} \begin{matrix} \leftarrow i[i1] \text{ is start of first minimums} \\ \\ \\ \leftarrow i[i2] \text{ is start of second minimums} \\ \\ \text{etc.} \\ i: 1 \times m, \quad m = n1 + n2 + \ldots \end{matrix} \quad \begin{matrix} \left.\begin{matrix} \\ \\ \\ \end{matrix}\right\} \text{has } n1 \text{ values} \\ \left.\begin{matrix} \\ \end{matrix}\right\} \text{has } n2 \text{ values} \end{matrix}$$

$j1$, $j2$, ..., are indices into v.

Conformability

`minindex(`v`, `k`, `i`, `w`)`, `maxindex(`v`, `k`, `i`, `w`)`:

input:

v:	$n \times 1$ or $1 \times n$	
k:	1×1	

output:

i:	$L \times 1$,	$L \geq K$
w:	$K \times 2$,	$K \leq \lvert k \rvert$

Diagnostics

`minindex(`v`, `k`, `i`, `w`)` and `maxindex(`v`, `k`, `i`, `w`)` abort with error if i or w is a view.

In `minindex(`v`, `k`, `i`, `w`)` and `maxindex(`v`, `k`, `i`, `w`)`, missing values in v are ignored in obtaining minimums and maximums.

In the examples above, we have shown input vector v as a row vector. It can also be a column vector; it makes no difference.

In `minindex(`v`, `k`, `i`, `w`)`, input argument k specifies the number of minimums to be obtained. k may be zero. If k is negative, $-k$ maximums are obtained.

Similarly, in `maxindex(`v`, `k`, `i`, `w`)`, input argument k specifies the number of maximums to be obtained. k may be zero. If k is negative, $-k$ minimums are obtained.

`minindex()` and `maxindex()` are designed for use when k is small relative to `length(`v`)`; otherwise, see `order()` in [M-5] **sort()**.

Also see

[M-5] **minmax( )** — Minimums and maximums

[M-4] **utility** — Matrix utility functions