CSE 142
Computer Programming I

Sorting

Overview

Sorting defined
Algorithms for sorting
Selection Sort algorithm
Efficiency of Selection Sort

Sorting

The problem: put things in order
- **Usually smallest to largest: "ascending"**
- **Could also be largest to smallest: "descending"**

Lots of applications!
- **ordering hits in web search engine**
- **preparing lists of output**
- **merging data from multiple sources**
- **to help solve other problems**
  - **faster search (allows binary search)**
- **too many to mention!**

Sorting: More Formally

Given an array b[0], b[1], ... b[n-1],
reorder entries so that
b[0] <= b[1] <= ... <= b[n-1]

Shorthand for these slides: the notation *array[i..k]* means all of the elements
array[i],array[i+1]...array[k]
Using this notation, the entire array would be:
b[0..n-1]

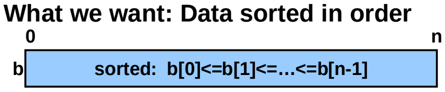
P.S.: This is not C syntax!

Sorting Algorithms

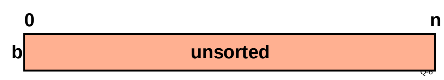
Sorting has been intensively studied for decades
Many different ways to do it!
We'll look at only one algorithm, called "Selection Sort"
- **Other algorithms you might hear about in other courses include Bubble Sort, Insertion Sort, QuickSort, and MergeSort. And that's only the beginning!**

Sorting Problem

What we want: Data sorted in order



Initial conditions



Selection Sort

General situation

	0	k	n
b	smallest elements, sorted	remainder, unsorted	

Strategy of the algorithm:

Grow the blue area, shrink the pink area

Q-7

Selection Sort

Step:

Find smallest element x in b[k..n-1]

Swap smallest element with b[k], then increase k

	0	k		n
b	smallest elements, sorted		x	

Q-8

Subproblem: Find Smallest

```
/* Find location of smallest element in b[k..n-1] */
/* Assumption: k < n */
/* Returns index of smallest, does not return the
   smallest value itself */
int min_loc (int b[ ], int k, int n) {
  int j, pos;  /* b[pos] is smallest element */
               /* found so far */
  pos = k;
  for ( j = k + 1; j < n; j = j + 1)
    if (b[j] < b[pos])
      pos = j;
  return pos;
}
```

Q-9

Code for Selection Sort

```
/* Sort b[0..n-1] in non-decreasing order
   (rearrange elements in b so that
   b[0]<=b[1]<=…<=b[n-1] ) */

void sel_sort (int b[ ], int n) {
  int k, m;
  for (k = 0; k < n - 1; k = k + 1) {
    m = min_loc(b,k,n);
    swap(&b[k], &b[m]);
  }
}
```

Q-10

Example

b	3	12	-5	6	142	21	-17	45

min_loc (at -17)

b	-17	12	-5	6	142	21	3	45

min_loc (at -5)

b	-17	-5	12	6	142	21	3	45

min_loc (at 3)

Q-11

Example (cont.)

b	-17	-5	3	6	142	21	12	45

min_loc (at 6)

b	-17	-5	3	6	142	21	12	45

min_loc (at 12)

b	-17	-5	3	6	12	21	142	45

min_loc (at 21)

Q-12

Example (concluded)

b								
	-17	-5	3	6	12	21	142	45

min_loc

b								
	-17	-5	3	6	12	21	45	142

Q-13

Sorting Analysis

How many steps are needed to sort n things?

For each swap, we have to search the remaining array

length is proportional to original array length *n*

Need about *n* search/swap passes

Total number of steps proportional to n^2

Conclusion: selection sort is pretty expensive (slow) for large *n*

Q-14

Can We Do Better Than n^2?

Sure we can!

Selection, insertion, bubble sorts are all proportional to n^2

Other sorts are proportional to *n log n*

- Mergesort
- Quicksort
- etc.

log n is considerably smaller than n, especially as n gets larger

As the size of our problem grows, the time to run a n^2 sort will grow much faster than an *n log n* one.

Any better than *n log n*?

In general, no. But in special cases, we can do better

Example: Sort exams by score: drop each exam in one of 101 piles; work is proportional to *n*

Curious fact: efficiency can be studied and predicted mathematically, without using a computer at all!

Q-16

Comments about Efficiency

Efficiency means doing things in a way that saves resources

Usually measured by *time* or *memory* used

Many small programming details have little or no measurable effect on efficiency

The big differences comes with the right choice of *algorithm* and/or *data structure*

Q-17

Summary

Sorting means placing things in order

Selection sort is one of many algorithms

At each step, finds the smallest remaining value

Selection sort requires on the order of n^2 steps

There are sorting algorithms which are greatly more efficient

It's the algorithm that makes the difference, not the coding details

Q-18