CS1110 6 April 2010

binary search, linear search

insertion sort, selection sort, quick sort

Do exercises on pp. 311-312 to get familiar with concepts and develop skill. Practice in DrJava! Test your methods!

Today, we will develop some of the algorithms that we mentioned last time. Then, we will move on to some of the algorithms shown in this handout.

These slides will be used next time, too. We will attempt to go slowly enough that you can all understand the concepts and learn to develop these algorithms.

Comments on A5

Liked not having to write test cases!

Recursion:

Make requirements/descriptions less ambiguous, clearer; give more direction.

Need optional problem with more complicated recursive solution would have been an interesting challenge, more recursive functions. They make us think!

Make task 5 easier. I could not finish it.

Needed too much help, took too long

Add more methods; it did not take long

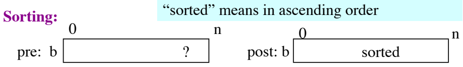
Allow us to do recursive methods with loops rather than recursively.

Good time drinking beer while watching the demo after I was done.

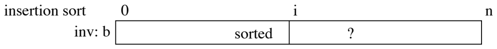
I had intended here to erupt in largely incoherent rage over that wretched concept of recursion, which I came to hate like an enemy: like a sentient being who, knowing the difference between right and wrong, had purposely chosen to do me harm. However, I then figured out how it works, and it is actually quite elegant, so now I suppose I have learned something against my will.

Sorting:

"sorted" means in ascending order

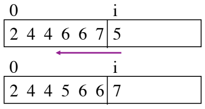

pre: b — 0 … n: ?

post: b — 0 … n: sorted


insertion sort

inv: b — 0 … i: sorted; i … n: ?

```
for (int i= 0;  i < n;  i= i+1) {
    Push b[i] down into its sorted
        position in b[0..i];
}
```


0 … i: 2 4 4 6 6 7 | 5

0 … i: 2 4 4 5 6 6 | 7

Iteration i makes up to i swaps.

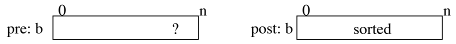
In worst case, number of swaps needed is $0 + 1 + 2 + 3 + … (n-1) = (n-1)*n / 2$.

Called an "n-squared", or n^2, algorithm.

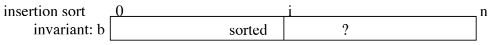
b[0..i-1]: i elements

in worst case:

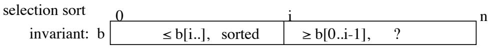
Iteration 0: 0 swaps
Iteration 1: 1 swap
Iteration 2: 2 swaps
…


pre: b — 0 … n: ?

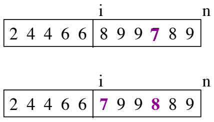
post: b — 0 … n: sorted


insertion sort invariant: b — 0 … i: sorted; i … n: ?

Add property to invariant: first segment contains smaller values.


selection sort invariant: b — 0 … i: ≤ b[i..], sorted; i … n: ≥ b[0..i-1], ?

```
for (int i= 0;  i < n;  i= i+1) {
    int j= index of min of b[i..n-1];
    Swap b[j] and b[i];
}
```


i … n: 2 4 4 6 6 | 8 9 9 7 8 9

i … n: 2 4 4 6 6 | 7 9 9 8 8 9

Also an "n-squared", or n^2, algorithm.

Quicksort

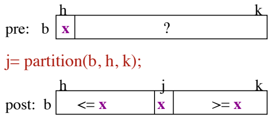
```
/** Sort b[h..k] */
public static void qsort(int[] b, int h, int k) {
      if (b[h..k] has fewer than 2 elements)
           return;

      int j= partition(b, h, k);
      // b[h..j–1] <= b[j] <= b[j+1..k]

      // Sort b[h..j–1]  and  b[j+1..k]

      qsort(b, h, j–1);

      qsort(b, j+1, k);

}
```

To sort array of size n. e.g. 2^{15}

Worst case: n^2 e.g. 2^{30}

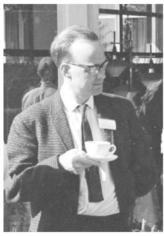
Average case: n log n. e.g. $15 * 2^{15}$

$2^{15} = 32768$


pre: b — h … k: x | ?

j= partition(b, h, k);

post: b — h … j … k: <= x | x | >= x


Tony Hoare,

in 1968

Quicksort author

Tony Hoare

in 2007

in Germany

Thought of Quicksort in ~1958. Tried to explain it to a colleague, but couldn't.
Few months later: he saw a draft of the definition of the language Algol 58 –later turned into Algol 60. It had recursion.
He went and explained Quicksort to his colleague, using recursion, who now understood it.

Viewpoint On teaching programming Reply

I don't like how we are forced to visualize things in Dr. Gries' way. … Entire point of programming is to be able to look at things in different ways and come up with different solutions for one problem. Forcing us to think of things in his way and testing us on it has been detrimental to my learning because in my opinion it wastes time and confuses me. This course should focus more on solving problems rather than drawing folders to represent objects.

1. A model of execution of Java programs is needed in order to bring understanding.

2. Problem solving *is* the focus. The programs you wrote for A5, the algorithms we are now studying, and the way we develop them, could not have been possible without the basics that we have given you.

3. We are giving you tools for coming up with *good* solutions, not just different ones.

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The NATO Software Engineering Conferences

homepages.cs.ncl.ac.uk/brian.randell/NATO/

7-11 Oct 1968, Garmisch, Germany
27-31 Oct 1969, Rome, Italy

Download Proceedings, which have transcripts of discussions.
See photographs.

Software crisis:
Academic and industrial people. Admitted for first time that they did not know how to develop software efficiently and effectively.

Software Engineering, 1968

Next 10-15 years: intense period of research of software engineering, language design, proving programs correct, etc.

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Software Engineering, 1968

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During 1970s, 1980s, intense research on
How to prove programs correct,
How to make it practical,
Methodology for developing algorithms

The way we understand recursive methods is based on that methodology.
Our understanding of and development of loops is based on that methodology.

Throughout, we try to give you thought habits to help you solve programming problems for effectively

Mark Twain: Nothing needs changing so much as the habits of **others**.

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The way we understand recursive methods is based on that methodology.
Our understanding of and development of loops is based on that methodology.

Throughout, we try to give you thought habits to help you solve programming problems for effectively

Simplicity is key:
Learn not only to simplify, learn not to complify.

Don’t solve a problem until you know what the problem is (give precise and thorough specs).

Separate concerns, and focus on one at a time.

Learn to read a program at different levels of abstraction.

Develop and test incrementally.

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