The Beauty and Joy of Computing

Lecture #6
Algorithms I

Jon Kotker
UC Berkeley
EECS 2010, 2013
(jkotker@berkeley.edu)
Microsoft

Ethical trap: robot paralysed by choice of who to save

http://www.newscientist.com/article/mg22329863.700#.VCBKo6x0z6E

What is an algorithm?

- An **algorithm** is any well-defined computational procedure that takes some value or set of values as input and produces some value or set of values as output.
- The concept of algorithms, however, is far older than computers.

Early Algorithms

- Dances, ceremonies, recipes, and building instructions are all conceptually similar to algorithms.
- Babylonians defined some fundamental mathematical procedures ~3,600 years ago.
- Genes contain algorithms!

Photo credit: Daniel Niles

Algorithms You've Seen in CS10

- Length of word
- Whether a word appears in a list
- Interact with the user (ask)
- Word Comparisons (You wrote one for HW1!)
- Sort a List (see lab!)
- Make this a block!

Algorithms You Might Have Heard Of

Luhn algorithm
Credit card number validation

Deflate
Lossless data compression

PageRank
Google's way of measuring "reputation" of web pages

EdgeRank
Facebook's method (ca. 2010) for determining what is highest up on your news feed

Announcements: Quest

- Wednesday, October 1.
- Short exam in class.
- Questions are mostly multiple-choice, circle the correct answer, indicate what happens, predict the output, and so on.
- Quest is a sanity check – if you have been showing up to lectures, labs and discussions, and you understand the overall concepts, you should be fine. If you do not understand something, *please ask for help*. The staff is always willing to help. ☺

Important Terms

Sequencing
Application of each step of an algorithm in order (sometimes: find order)

Selection
Use of Boolean condition to select execution parts

Iteration
Repetition of part of an algorithm until a condition is met

Recursion
Repeated application of the same part of algorithm on smaller problems

Properties of Algorithms

- Algorithm + Algorithm = Algorithm
- Part of Algorithm = Algorithm
- Algorithms can be efficient or inefficient given a comparison algorithm
- Several algorithms may solve the same problem

Algorithm Correctness

We don't only want algorithms to be fast and efficient; we also want them to be ***correct!***

TOTAL Correctness
Always reports, and the answer is always correct.

PARTIAL Correctness
Sometimes reports, and the answer is always correct *when it reports*.

We also have *probabilistic* algorithms that have a certain *probability* of returning the right answer.

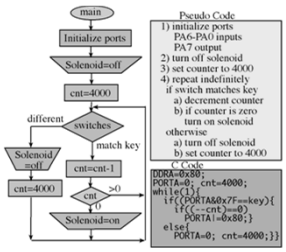
How to Express Algorithms…

A programmer's spouse tells him: "Run to the store and pick up a loaf of bread. If they have eggs, get a dozen." The programmer comes home with 12 loaves of bread.

Algorithms need to be expressed in a context-free, unambiguous way for all participants.

Ways to Express Algorithms

- Natural Language
- Pseudo Code
- Programming Language
- …or in any other information conveying way!



Programming Languages

C/C++
Good for programming that is close to hardware

Java/C#
Portable code

Python/Perl/TclTK
Fast to write and portable

BASIC/BYOB/SNAP
Good for teaching programming concepts

All programming languages can be used to implement (almost) any algorithm!

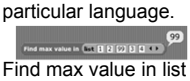
Choosing a Technique

- Most problems can be solved in more than one way, i.e., multiple algorithms exist to describe how to find the solution.
- The right language makes formulating algorithms easier and clearer.
- Not all of these algorithms are created equal. Very often we have to make some trade-offs when we select a particular one.
- There are unsolvable problems!

Algorithms vs. Functions and Procedures

- Algorithms are conceptual definitions of how to accomplish a task and are language agnostic, usually written in pseudo-code.
- Find max value in list
  - Set (a temporary variable) the max as the first element
  - Go through every element, compare to max, and if it's bigger, replace the max
  - Return the max

- A function or procedure is an implementation of an algorithm, in a particular language.



- Find max value in list

Summary

- The concept of an algorithm has been around forever, and is an integral topic in CS.
- Algorithms are well-defined procedures that can take inputs and produce output. Programming languages help us express them.
- We're constantly dealing with trade-offs when selecting / building algorithms.
- Correctness is particularly important and testing is the most practical strategy to ensure it.
  - Many write tests first!