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The Beauty and Joy of Computing

Lecture #6 Algorithms I



University students 'made to wear anti-cheating helmets'
Students in Thailand appear to have been forced to wear helmets to prevent them from cheating during exams.



In an effort to curb rampant cheating, Bangkok's Kasetsart University created an anti-deceit paper helmet for students to wear during their midterm exams. Photo: Facebook



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 for determining what is highest up on your news feed



Important Terms

Sequencing

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

Selection

Use of Boolean condition to select execution part

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...

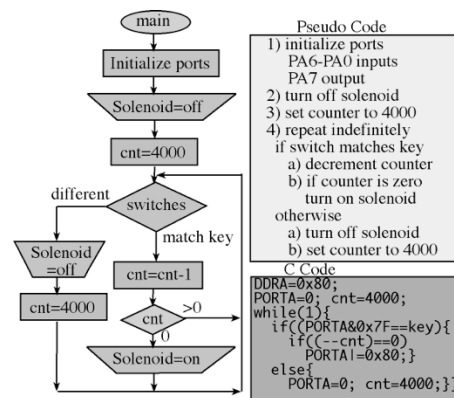
A programmer's spouse tells him: "Run to the store and pick up a loaf of bread. If they have eggs, get a dozen." The programmer comes home with 12 loaves of bread.

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/Tcl/TK

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 & 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

```
Find max value in list [ 1 2 99 3 4 ]
```

```
find-max-in list :  
script variables the max  
set the max to item 1 of list  
for each item of list  
if item > the max  
set the max to item  
report the max
```



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!

