



The Beauty and Joy of Computing

Lecture #6 Algorithms




Optimal Algorithm For Finding Waldo...

A researcher used a genetic algorithm – one that “evolves” over different generations, and competes against a metric of success (here, distance the eye has to travel) to find the optimal search path for finding Waldo.




“Where’s Waldo?” optimal search path


www.randallolson.com/2015/02/03/wheres-waldo-computing-the-optimal-search-strategy-for-finding-waldo/



Algorithms: Definitions

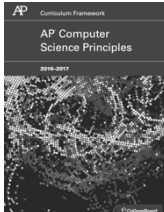



(AP) Computer Science Principles




7 Big Ideas


- Creativity
- Abstraction
- Data and Information
- Algorithms
- Programming
- The Internet
- Global Impact





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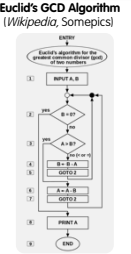





Algorithm: Definition

en.wikipedia.org/wiki/Algorithm


- “Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.”
- The concept of algorithms, however, is far older than computers.




Euclid's GCD Algorithm
(Wikipedia, Somepics)




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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!




Woman Basket Weaving
(Wikipedia, Public Domain)




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Algorithms You've Seen in BJC so far

- 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!)



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Algorithms You May Already Know

Luhn algorithm
Credit card number validation

PageRank
Google's way to measure web page "reputation"

Levenshtein Distance
Determine "edits" in 2 words – used for autocorrect

EdgeRank
Facebook's way to determine news feed sort

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Precursor: The Internet

Routing Your Data
Many algorithms exist to transfer data to new places in the shortest distance

RSA
A core algorithm that enabled internet security for safe online activity.

Congestion Control
"TCP" controls how data is sent – many ways to do this efficiently to keep traffic smooth

Searching / Sorting
Thousands of options. Tasks are at the core of almost every website.

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Building Blocks of Algorithms

Sequencing
Application of each step of an algorithm in order given

```

graph TD
    A[Do This] --> B[Then this]
    B --> C[And finally that]
        
```

Selection
Use of Boolean condition to select which of two parts to do

```

graph TD
    A{some test} -- yes --> B[Do This]
    A -- no --> C[Do That]
        
```

Iteration
Repetition algorithm part # times or until condition met

```

graph TD
    A[repeat 10] --> B[Do This]
    B --> C[repeat until some test]
    C --> B
        
```

Recursion
The overall algorithm calls itself to help solve the problem on smaller parts, combine result. (we'll see later)

Every algorithm can be constructed using only Sequencing, Selection, & Iteration!

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Which of the following is *false*?

a) Algorithms can be worth *billions* of \$

b) Paul Revere practiced *selection*

c) You learned your first algorithm before you could speak

d) Proving algorithms are *correct* is easy

e) Algorithms can *adapt*, like a living thing

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Algorithms: Properties, Expressing

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Properties of Algorithms

- Algorithms can be combined to make new algorithms.
- Using existing correct algorithms as building blocks for constructing a new algorithm helps ensure the new algorithm is correct.
- Knowledge of standard algorithms can help in constructing new algorithms
- Different algorithms can be developed to solve the same problem.
- Developing a new algorithm to solve a problem can yield insight into the problem

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How to Express Algorithms...

A programmer's spouse says: "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!

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Languages for Algorithms

- Natural Language, Pseudo Code
 - For Humans to understand
- Visual & Text-based Programming Languages
 - Can be run on a computer
 - ...or in any other information conveying way!

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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

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Which Language to Choose?

- Different languages are better suited for expressing different algorithms
- Some programming languages are designed for specific domains and are better for expressing algorithms in those domains
- The language used to express an algorithm can affect characteristics such as clarity or readability but not whether an algorithmic solution exists
- Clarity and readability are important considerations when expressing an algorithm in a language.

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Programming Languages

C/C++ Good for programming that is close to hardware	Java/C# Portable code
Python/Perl/TclTK Fast to write and portable	Scratch/Snap! Good for teaching programming concepts

Nearly all programming languages are equivalent in terms of being able to express any algorithm!

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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.
- Each paradigm / language has its unique benefits
 - All Turing complete languages are equally powerful
 - Paradigms vary in efficiency, scalability, overhead, fun, "how" vs "what", ...

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