Michael Ball

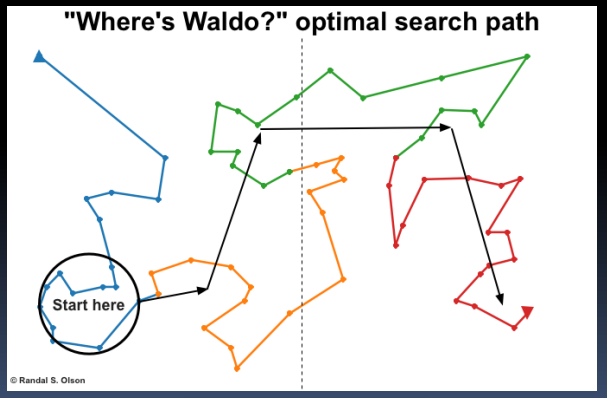
The Beauty and Joy of Computing

Lecture #6 Algorithms

bjc

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.



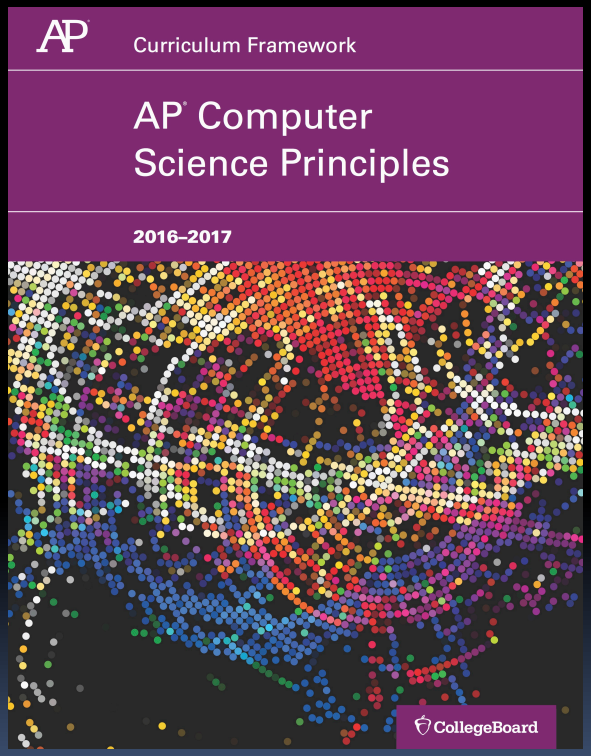
www.randalolson.com/2015/02/03/heres-waldo-computing-the-optimal-search-strategy-for-finding-waldo/

Algorithms: Definitions

(AP) Computer Science Principles

7 Big Ideas

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

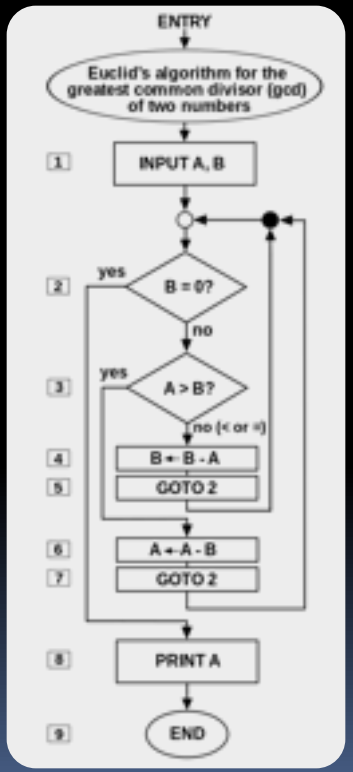


Algorithm: Definition

- "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)



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)

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!)

Algorithms You May Already Know

Luhn algorithm
Credit card number validation

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

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

EdgeRank
Facebook's way to determine news feed sort

Precursor: The Internet

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

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

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

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

Building Blocks of Algorithms

Sequencing

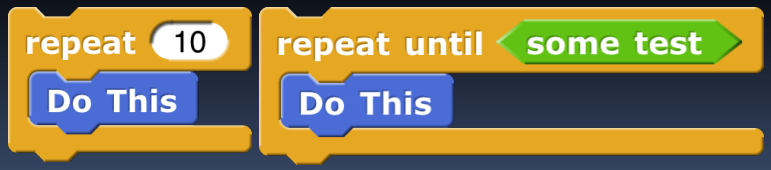
Application of each step of an algorithm in order given

Selection / Conditionals

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

Iteration

Repetition algorithm part # times or until condition met



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!

Algorithms: Properties, Expressing

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

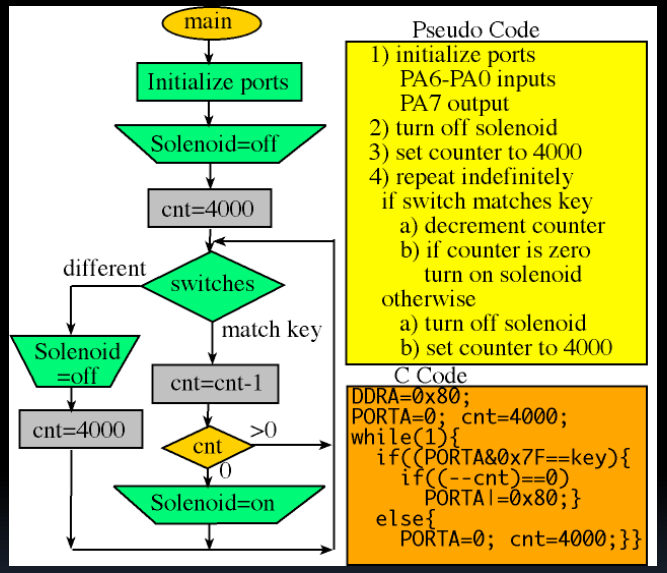
How to Express Algorithms…

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!

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!



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

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

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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What makes for the best algorithm?

a) Runs the quickest

b) Shortest lines of code

c) Easiest to understand

d) Uses less memory or space

e) Produces the most correct answer

Ball

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", …