CSC 421: Algorithm Design & Analysis

Spring 2019

See online syllabus: http://dave-reed.com/csc421 (also on BlueLine)

Course goals:

- To appreciate the role of algorithms in problem solving and software design, recognizing that a given problem might be solved with a variety of algorithms.
- To be capable of selecting among competing algorithms and justifying their selection based on efficiency.
- To be capable of selecting and utilizing appropriate data structures in implementing algorithms as computer programs.
- To develop programs using different problem-solving approaches (divide-and-conquer, backtracking, dynamic programming), and be able to recognize when one approach is a better fit for a given problem.
- To design and implement programs to model real-world systems, and subsequently analyze their behavior.

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Your programming evolution…

221: programming in the small

- focused on the design & implementation of small programs
- introduced fundamental programming concepts
  - ✓ variables, assignments, expressions, I/O
  - ✓ control structures (if, if-else, while, for), strings, lists
  - ✓ functions, parameters, OO philosophy

222: programming in the medium

- focused on the design & analysis of more complex programs
- introduced object-oriented approach
  - ✓ classes, objects, fields, methods, object composition, libraries
  - ✓ interfaces, inheritance, polymorphism, system modeling
  - ✓ searching & sorting, Big-Oh efficiency, recursion, GUIs

you should be familiar with these concepts (we will do some review next week, but you should review your own notes & text)

321: programming in the larger

- focus on more complex problems where data structure choices matter
- introduce standard data structures, design techniques, performance analysis
  - ✓ stacks, queues, sets, maps, linked structures, trees, graphs, hash tables
  - ✓ algorithm design, data structure selection/comparison/analysis
  - ✓ algorithm analysis, recurrence relations, counting & proof techniques

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421: programming in the even larger

still not developing large-scale, multi-programmer systems

- see CSC 548, CSC 599

we will tackle medium-sized (3-10 interacting classes) projects in which

- there may be multiple approaches, with different performance characteristics
- the choice of algorithm and accompanying data structure is important
- the wrong choice can make a solution infeasible

- we will consider multiple design paradigms and problem characteristics that suggest which paradigm to apply
  - ✓ brute force, decrease & conquer, divide & conquer, transform & conquer
  - ✓ greedy algorithms, backtracking, dynamic programming, space/time tradeoffs

- we will also study the notions of computability and feasibilty
  - ✓ P vs. NP, NP-hard problems, approximation algorithms

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When problems start to get complex…

…choosing the right algorithm and data structures are important

- e.g., phone book lookup, checkerboard puzzle

- must develop problem-solving approaches (e.g., divide&conquer, backtracking)
- be able to identify appropriate data structures (e.g., lists, trees, sets, maps)

		1			2			
	3	7	8					2
2	4						7	3
4						7	1	
				6		8		
	8	2						9
9	5						3	7
6					5	4	8	
				4		5		

EXAMPLE: solving a Sudoku puzzle

- need to be able to represent the grid
- devise an algorithm to fill in the blanks so that every row, column & subsquare contains 1-9

- how do you solve Sudoku puzzles?
- should the computer use the same approach?
- how complicated/fast would it be?

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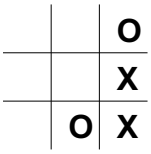
Another example

consider two-player, perfect-knowledge strategy games

- e.g., tic-tac-toe, checkers, chess



what is X's rational move?

- need to be able to represent the board
- identify winning/losing state
- select the best move at any given state of the game

what is white's rational move?

- how do you play tic-tac-toe? chess?
- should the computer use the same approach?
- are the approaches to tic-tac-toe and chess similar?

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Another example

suppose you are given a set of integers (positive and negative)

{ 4, -9, 3, 4, -1, -5, 8 }

is there a subset of integers that add up to 0?

- this is known as the *subset sum problem*
- it turns out that there is no known efficient algorithm to solve this
- may have to exhaustively try every possible subset of numbers
- how many subsets of N items can there be?

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OOP and code reuse

when solving large problems, code reuse is important

- designing, implementing, and testing large software projects is HARD
  whenever possible, want to utilize existing, debugged code
- reusable code is:
  clear and readable (well documented, uses meaningful names, no tricks)
  modular (general, independent routines – test & debug once, then reuse)

OOP is the standard approach to software engineering

philosophy: modularity and reuse apply to data as well as functions

- when solving a problem, must identify the objects involved
  e.g., banking system: customer, checking account, savings account, …
- develop a software model of the objects in the form of abstract data types (ADTs)
  a program is a collection of interacting software objects
  can utilize inheritance to derive new classes from existing ones

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