CS120 Fall 2021:
Introduction to Algorithms and their Limitations

Content Plan

As mentioned in the Syllabus, this is subject to modification based on how the course is going.

1. Course preview (1 class, on Zoom)
2. Storing, sorting, and searching data (6 classes)
    a. Motivating problems: aspects of web search, interval scheduling, robust statistics (medians), rendering back-to-front in graphics, deduplication
    b. Review of sorting from CS50: selection, bubble, mergesort
    c. Lower bound for sorting in the comparison model
    d. Offline and online interval scheduling via data structures
    e. Data structure problems for ordered sets
    f. Balanced binary search trees
    g. Randomized selection in linear time
    h. Time permitting: randomized quicksort
    i. The Word-RAM model and equivalence with Python
    j. Dictionaries & hash tables
3. Graph Algorithms (4 classes)
    a. Motivating problems: finding road directions, confirming connectivity of a cellular network, register allocation, scheduling problems, task assignment problems, solving puzzles, model checking, map coloring
    b. Representing graphs - adjacency matrix vs. adjacency lists.
    c. Graph search - BFS & DFS and applications, and random walks (if time permits)
    d. Vertex Partition problems: graph coloring and independent sets
    e. Edge Partition problems: maximum matching and edge coloring
4. Logic Algorithms (4 classes)
    a. Motivating problems: program/circuit verification, expressiveness to encode other problems
    b. Propositional satisfiability and relation to other problems
    c. Resolution
    d. Exponential-time SAT and MIP solvers
    e. If time permits: SMT solvers and use in program verification
5. Computability Theory (4 classes)
    a. The Church-Turing Thesis
    b. The Universal Python Program
    c. The halting problem and its undecidability
    d. Uncomputability via reductions
6. Computational Complexity (4 classes)

    a. The Extended Church-Turing Thesis
    b. The P vs. NP Problem
    c. NP-completeness
7. Geometric Algorithms (2 classes if time permits, some subset of below)
    a. Motivating problem domain: graphics, robotics
    b. Closest pair problem
    c. Convex hulls
    d. Planar graphs
8. Conclusions (1 class)