CSE 421: Review

Larry Ruzzo

CSE 521: Review

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Complexity, I

Asymptotic Analysis

Best/average/**worst** cases

Upper/Lower Bounds

Big O, Theta, Omega

Analysis methods

- loops
- recurrence relations
- common data structures, subroutines

Complexity, I

Asymptotic Analysis

Best/average/**worst** cases

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Analysis methods

- loops
- recurrence relations
- common data structures, subroutines
- "progress" arguments and general brute cleverness…

Graph Algorithms

Graphs

- Representation (edge list/adjacency matrix)
- Breadth/depth first search
- Bipartitness/2-Colorability
- DAGS and topological ordering

Graph Algorithms

Graphs

- Representation (edge list/adjacency matrix)
- Breadth/depth first search
- Connected components
- Shortest paths/bipartitness/2-Colorability
- DAGS and topological ordering
- DFS/articulation points/biconnected components

Graph Algorithms

Graphs

- Breadth/depth first search
- Connected components
- Shortest paths/bipartitness/2-Colorability
- DAGS and topological ordering
- DFS/articulation points/biconnected components
- Strongly connected components

Design Paradigms

Greedy

Dynamic Programming

- recursive solution, redundant subproblems, few
- do all in careful order and tabulate

Divide & Conquer

- recursive solution
- superlinear work
- balanced subproblems

Design Paradigms

Greedy

- emphasis on correctness arguments, e.g. stay ahead, structural characterizations, exchange arguments

Divide & Conquer

- recursive solution, superlinear work, balanced subproblems, recurrence relations, solutions, Master Theorem

Later:

- Dynamic Programming
- Powerful Subproblems
  - Flow, Matching, Linear Programming

Design Paradigms

Greedy

emphasis on correctness arguments, e.g. <u>exchange</u>

Divide & Conquer

recursive solution, superlinear work, balanced sub-problems, recurrence relations, solutions, Master Thm

Dynamic Programming

recursive solution, redundant subproblems, few

do all in careful order and tabulate; <u>OPT function</u>

(usually far superior to “memoization”)

Powerful Subproblems

Flow, Matching, Linear Programming

Design Paradigms

Greedy

- emphasis on correctness arguments, e.g. exchange

Divide & Conquer

- recursive solution, superlinear work, balanced subproblems, recurrence relations, solutions, Master Thm

Dynamic Programming

- recursive solution, redundant subproblems, few
- do all in careful order and tabulate; OPT function
- (usually far superior to “memoization”)

Powerful Subproblems

- Flow, Matching, Linear Programming

Examples

Greedy

- Interval Scheduling Problems (3)
- Huffman Codes
- Examples where greedy fails (stamps/change, scheduling, knap, RNA,…)

Examples

Divide & Conquer

- Merge sort
- Counting Inversions
- Closest pair of points
- Integer multiplication (Karatsuba)
- Matrix multiplication (Strassen)
- Powering

Examples

Divide & Conquer

- Merge sort
- Closest pair of points
- Integer multiplication (Karatsuba)
- Matrix multiplication (Strassen)
- Powering
- FFT

Midterm Friday

Closed book, no notes

(no bluebook needed; scratch paper may be handy; calculators unnecessary)

All up through “Divide & Conquer”

- assigned reading up through Ch 5;
- slides
- homework & solutions

Examples

Dynamic programming

- Fibonacci
- Making change/Stamps
- Weighted Interval Scheduling
- RNA

Examples

Dynamic programming

- Weighted Interval Scheduling
- Max Subarray Sum
- Knapsack
- String Search with Wildcards
- Edit Distance/String Alignment
- Counting Solutions
- Shortest Paths
- RNA Folding

OPT function

Examples

Dynamic programming

- Fibonacci
- Making change/Stamps, Knapsack
- Weighted Interval Scheduling
- RNA
- String Alignment

OPT function

Examples

Dynamic programming

- Fibonacci
- Making change/Stamps, Knapsack
- Weighted Interval Scheduling
- RNA
- String Alignment
- (code generation)

OPT function

Examples & Concepts

Flow and matching

- Residual graph, augmenting paths, max-flow/min-cut, Ford-Fulkerson and Edmonds-Karp algorithms, (preflow-push), integrality, reductions to flow, e.g. bipartite matching

Complexity, II

P vs NP

- Big-O and poly vs exponential growth
- Definition of NP – hints/certificates and verifiers
- Example problems from slides, reading & hw
  - SAT, VertexCover, quadratic Diophantine equations, clique, independent set, TSP, Hamilton cycle, coloring, max cut
- P $\subseteq$ NP $\subseteq$ Exp (and worse)
- Definition of (polynomial time) reduction
- SAT $\leq_p$ VertexCover example (how, why correct, why $\leq_p$, implications)
- Definition of NP-completeness
- 2x approximation to Euclidean TSP

Complexity, II

P vs NP

- Big-O and poly vs exponential growth
- Definition of NP – hints/certificates and verifiers
- Example problems from slides, reading & hw
  - SAT, 3-SAT, circuit SAT, vertex cover, quadratic Diophantine equations, clique, independent set, TSP, Hamilton cycle, coloring, max cut, knapsack
- P $\subseteq$ NP $\subseteq$ Exp (and worse)
- Definition(s) of (polynomial time) reduction
- SAT $\leq_p$ e.g., IndpSet, Knap, Ham, 3color: how, correctness, $\leq_p$, implications)
- Definition of NP-completeness
- NP-completeness proofs
- 2x, 1.5x approximations to Euclidean TSP

Complexity, II

P vs NP

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- P $\subseteq$ NP $\subseteq$ Exp (and worse)
- Definition(s) of (polynomial time) reduction
- SAT $\leq_p$ IndpSet, Knap examples (how, why correct, why $\leq_p$, implications)
- Definition of NP-completeness
- NP-completeness proofs
- Asymmetry; SAT vs UNSAT, (polynomial hierarchy, PSPACE)
- 2x, 1.5x approximations to Euclidean TSP

And see how relevant it is to your daily life!

Classic Nintendo Games are (NP-)Hard

Greg Aloupis* Erik D. Demaine† Alan Guo†‡

March 9, 2012

Abstract

We prove NP-hardness results for five of Nintendo's largest video game franchises: Mario, Donkey Kong, Legend of Zelda, Metroid, and Pokémon. Our results apply to Super Mario Bros. 1, 3, Lost Levels, and Super Mario World; Donkey Kong Country 1–3; all Legend of Zelda games except Zelda II: The Adventure of Link; all Metroid games; and all Pokémon role-playing games. For Mario and Donkey Kong, we show NP-completeness. In addition, we observe that several games in the Zelda series are PSPACE-complete.

Final Exam Mechanics

Closed book, 1 pg notes (8.5x11, 2 sides, handwritten)

(no bluebook needed; scratch paper may be handy; calculators unnecessary)

Comprehensive: All topics covered

- assigned reading
- slides
- homework & solutions

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Comprehensive, w/ post-midterm bias

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Some Typical Exam Questions

Give O( ) bound on 17n*(n-3+logn)

Give O( ) bound on some code `{for i=1 to n {for j …}}`

True/False: If X is O(n^2), then it's rarely more than n^3 +14 steps.

Explain why a given greedy alg is/isn't correct

Give a run time recurrence for a recursive alg, or solve a simple one

Convert a simple recursive alg to a dynamic programming solution

Simulate any of the algs we've studied

Give an alg for problem X, maybe a variant of one we've studied, or prove it's in NP

Understand parts of correctness proof for an algorithm or reduction

Implications of NP-completeness

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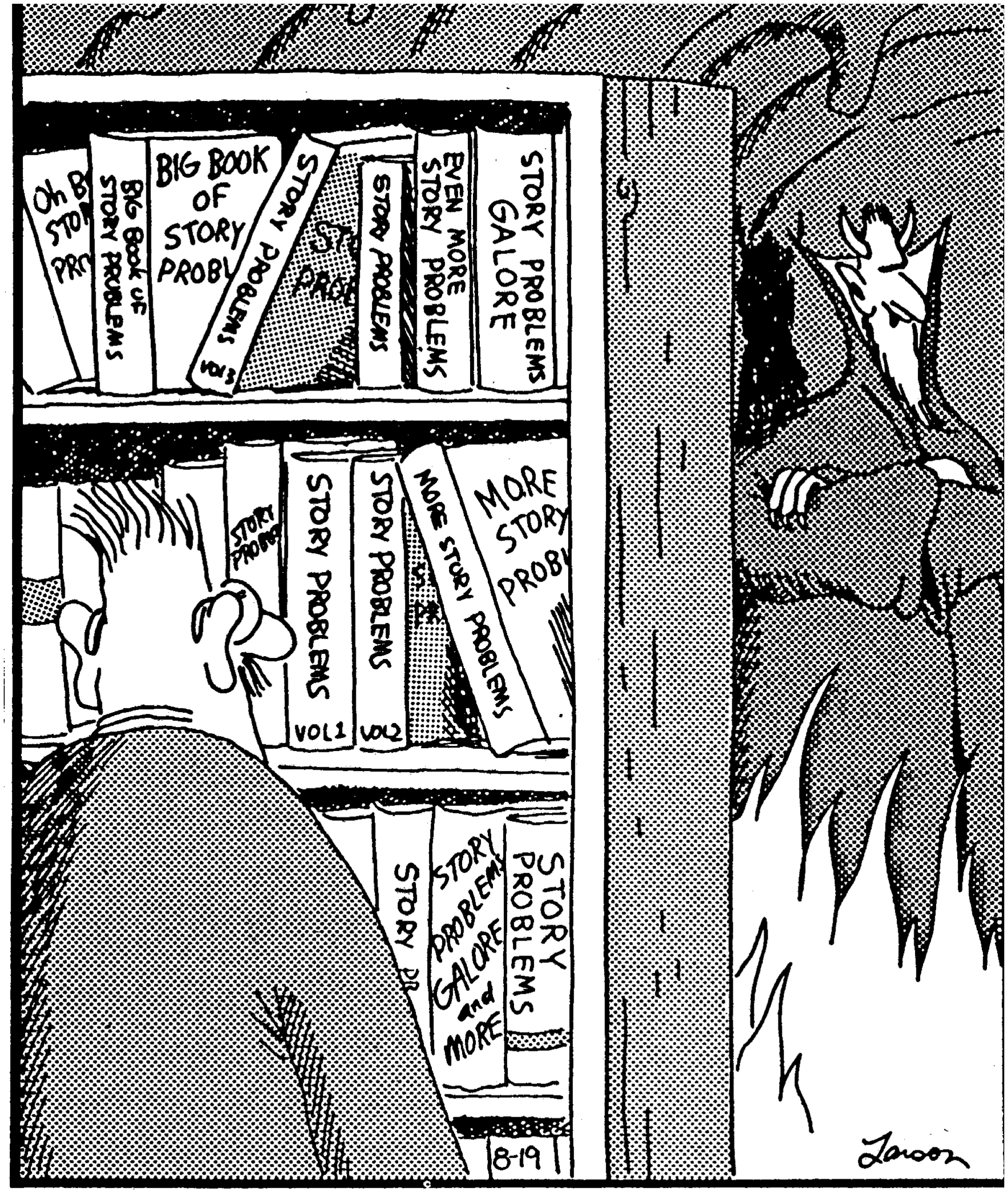
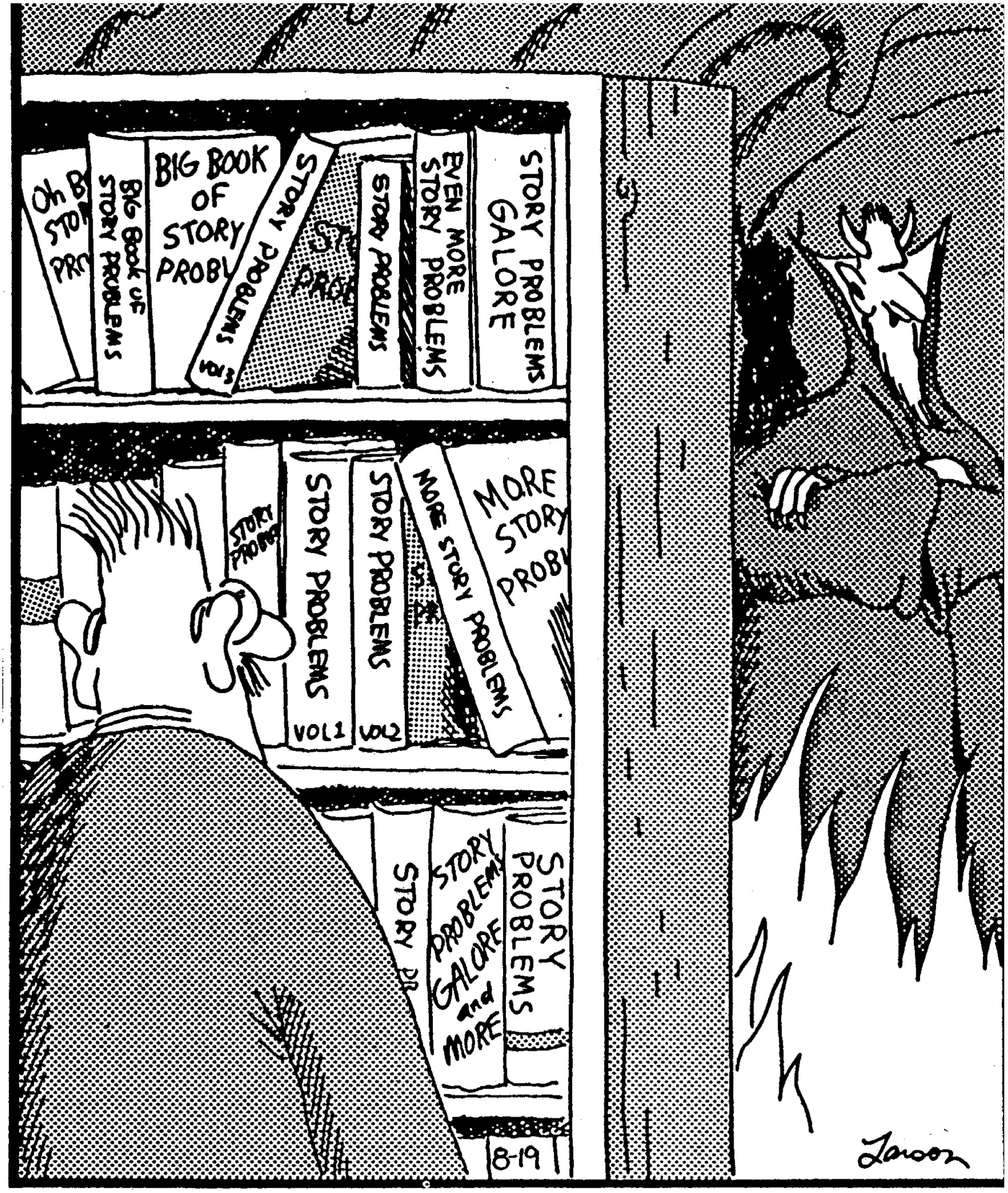
Reductions

NP-completeness proofs



~~Hell's library~~ → 421 Final



~~Hell's library~~ → 521 Final