Algorithm Design and Analysis (XXIV)

Conclusion

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What Is Algorithm

Algorithm Design

Basic algorithms:

- Recursion
- Algorithms on Lists, Trees and Graphs

Algorithm Design

Basic algorithms:

- Recursion
- Algorithms on Lists, Trees and Graphs

Advanced strategies:

- Divide and Conquer
  - Master Theorem
- Dynamic Programming
- Greedy
- Duality
- Reduction
- Backtracking Branch and Bound Local Search
- Approximation
- Randomization

Graphs

- undirected graphs, directed graphs.
- DAG.
- bipartite.
- graphs with weights.
- ...

Algorithms on Special Structures

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Network flows

- Ford-Fulkerson algorithm, Edmonds-Karp algorithm
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Computational Geometry

Big-O Notation (Ω, Θ)

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Advanced Methodology:

- Probability Analysis
- Amortized Analysis
- Competition Analysis

Standard Algorithms

- Sorting
- Searching & Hashing
- Strongly connected components
- Finding shortest paths in graphs
- Edit distances
- Minimum spanning trees in graphs
- Matchings in bipartite graphs
- Maximum flows in networks

Data Structure

- Balance trees, red-and-black trees
- Kripke structure, automata
- Priority queue
- Disjoint set
- Ordered binary decision diagrams (OBDD)
- ...

Computational Complexity

Church-Turing Thesis

Complexity class

- P, NP, Co-NP, NPI, NP-complete
- PSPACE
- RP, ZPP

Handling hard problems

- Simplex, DPLL(CDCL)(backtracking)
- Approximation
- local search
- treewidth

The Door of Algorithms Will Open!

Algorithmic View of Algorithms

Algorithms Strategies

SHANGHAI JIAO TONG UNIVERSITY

	D&C	DP	Greedy	Reduction	Duality
Basic topics	merge sort, median, matrix multiplication	LCS, edit distance, matrix chain multiplication	MST, Huffman encoding	graph/tree algorithm	max-flow/min-cut algorithms, maximal matching/vertex cover
Theoretical analysis	master theorem Akra-Bazzi theorem	time-space transformation, top-down, bottom-up	-	efficient/inefficient problems	primal-dual, simplex
Advanced topics	FFT	Sequence Alignment, Markov chain, treewidth	approximation algorithms	complexity classes, Karp reduction, Turing reduction	Lagrange duality, approximation algorithms

Algorithms on Data Structures

	Graphs	Flows	Numbers	...
Basic topics	DFS, BFS, DAG, shortest path, MST	Ford-Fulkerson algorithm	basic arithmetic, modular arithmetic	...
Theoretical analysis	priority queue, disjoint set, proof techniques	well-formed structures	expectation analysis, probability analysis,	...
Advanced topics	SCC, negative-cost path, GI	Dinitz algorithms, dynamic tree algorithms	RSA algorithm	...

Practical Algorithms

Q: Does Algorithm lecture provides practical, engineering algorithms?

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A: Not really.

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The terminology of algorithm in the *lecture* is quite different from the terminology of algorithm in *algorithm engineer*.

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Engineering/ Practical algorithms	Engineering FFT	time/space compression	Boruvka algorithm, clustering	DPLL/CDCL algorithms, invariant generation	deep learning explanation and verification

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Advanced topics	SCC, negative-cost path, GI	Dinitz algorithms, dynamic tree algorithms	RSA algorithm	...
Engineering/ Practical algorithms	Tarjan algotihm, algorithmic formal verification	push-relabelling algoithm	Miller-Rabin algorithm	...

Lecture Agenda

- More on Graph Algorithms
- More on Dynamic Programming
- Network Flows
- Linear Programming
- NP Problem
- Approximation Algorithms

Remarks

Remark

Hand in ALL homework!

Remark

Theorem Proving is a definite choice!

Graphs Algorithms

Graphs Algorithms

Theorem proving.

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- DAG, SCC.
- cut theorem.
- shortest path.
- theorems on trees.

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Algorithms on graph, based on SCC, shortest path, etc.

Theorem proving.

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Algorithms on graph, based on SCC, shortest path, etc.

More advanced topics.

Dynamic Programming

Algorithm design.

Entry of the recursive function.

Result location.

Time and space complexities.

Network Flows

Theorem proving.

- Max-flow min-cut theorem.
- etc.

Theorem proving.

- Max-flow min-cut theorem.
- etc.

Reduction.

Linear Programming

Primal and dual.

Primal and dual.

Problem representation.

NP Problem

NP Problem

NPC problem.

NP problem.

Approximation Algorithms

Approximation algorithm design.

Approximation guarantee factor proof.

Tight examples.