Advanced Algorithms (CS6L007)

Books

1. **[DPV]** Algorithms - Sanjay Dasgupta, Christos Papadimitriou, Umesh Vazirani
2. **[KT]** Algorithm Design - Jon Kleinberg and Eva Tardos
3. **[CLRS]** Introduction to Algorithms (Third Edition) - Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein

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Week 1: Lectures (July 25, 2024) and (July 26, 2024):

a) Introduction to Algorithms, Correctness and Efficiency of an algorithm, case study: Fibonacci Numbers and Insertion Sort.
b) Worst-case analysis of an algorithm
c) Models of computation - Word-RAM model
d) Asymptotic Analysis: Big O, Omega, Theta
e) Some examples of different upper bounds

Reference: Chapter 1 in DPV, Chapter 2 in KT, Chapter 2 (Section 2.1 and 2.2) in CLRS

Week 2: Lectures (August 1, 2024) and (August 2, 2024):

Algorithm Design Technique 1: Divide and Conquer

a) Multiplying two n-bit numbers (Karatsuba and Ofman)
b) Proof of Master Theorem
c) Matrix Multiplication (Strassen)
d) A problem in computational geometry : Finding closest pair of points
e) Counting Inversions
f) Finding Maximum Sum Subarray

Reference: Chapter 2 in DPV, Chapter 4 in KT, Section 4.1 in CLRS

Week 3: Lectures (August 8, 2024) and (August 9, 2024):

Proving Lower Bounds

a) Lower bound using Decision Tree model
   (Information Theoretic Argument) :
   Case study: Comparison Sorting Algorithms, Searching a sorted sequence, Merging two sorted sequence
b) Limitation of Information Theoretic Argument and need for Adversary Argument
c) Lower bound using Reduction

Reference: Toniann Pitassi's **Notes** and Section 8.1 in CLRS

Week 4: Lectures (August 15, 2024: Holiday) and (August 16, 2024):

Graph Algorithms

a) s-t connectivity problem
b) Correctness proof of Breadth-First Search (BFS), BFS tree properties
c) Application of BFS: Testing Bipartiteness and Finding diameter in a tree
d) Depth-First Search (DFS) in directed graphs and DFS tree properties
e) Application of DFS in directed graphs: Detecting Directed Acyclic Graphs, Topological Sort, Finding Strongly Connected Components

Reference: Chapter 3 in KT, Chapter 22 in CLRS

Week 5: Lectures (August 22, 2024) and (August 23, 2024):

Amortized Analysis

a) Aggregate Method
b) Accounting Method
c) Potential Method
d) Dynamic Tables (Expansion and Contraction)

Reference: Chapter 17 in CLRS

Week 6: Lectures (August 29, 2024) and (August 30, 2024):

Algorithm Design Technique 2: Greedy

a) Interval Scheduling Problem: optimality proof using “ Greedy stays ahead” strategy
b) Interval Coloring Problem: optimality proof using structural lower bound argument
c) Interval Scheduling to minimize lateness: optimality proof using exchange argument
d) Introduction to Matroid Theory

Reference: Chapter 5 in KT and Section 16.4 in CLRS