CSE 674

Advanced Data Structures and Algorithms

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Introduction

1. Data Structures + Algorithms = Programs
2. Data structures
   - 2.1 Sequential allocation (Arrays)
   - 2.2 Linked allocation (Pointers)

Elementary data structures

1. Elementary data structures: stacks, queues, deques, and vectors
2. Data structures as abstract data types

Trees, graphs, and hash tables

1. Trees as data structures
2. Data structures and basic traversal algorithms for graphs
3. Hash tables

Algorithm design methods

1. Divide and conquer
2. Dynamic programming
3. Greedy methods

Others

1. Data compression algorithms
2. Memory management

Elementary Data Structures

Elementary data structures

1. Stacks (LIFO), queues (FIFO)
2. Generalization: deques
3. Vectors and amortized analysis

Discussions on elementary data structures I

Stacks

Discussions on elementary data structures II

Queues

Discussions on elementary data structures III

Vectors

Sorting Methods

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Sorting

1. Basic sorting methods: Selection sort, insertion sort, bubble sort
2. In-place sorting; stable sorting
3. Tree-based sorting methods: heap sort and its variants
4. Divide-and-conquer based sorting methods: Merge sort, quick sort
5. Comparison-based sorting
6. Non-comparison-based sorting methods

Discussions on basic methods

Selection Sort **Insertion Sort** **Bubble Sort**

Discussions: In-place sorting and stable sorting

In-Place Sorting

Stable Sorting

Discussions on heap sort and related ideas

Heaps and Heap Sort **Priority Queue**

Discussions on divide-and-conquer based sorting methods

Quick Sort

Merge Sort

Discussions on comparison-based sorting methods

Comparison-Based Sorting

Non-Comparison-Based Sorting

Trees


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Trees

1. Trees and their general properties
2. Trees as data structures
3. Traversal methods and threading
4. Binary trees and search

Discussions on general properties of trees

Free Trees

Concepts

Discussions: Tree as data structures

Rooted Trees

Key Features

Discussions: Traversal methods

Pre-Order **In-Order** **Post-Order**

Discussions: Binary trees and threading

Binary Trees

Key Features

Threading

Key Ideas

Discussions: Binary trees and search

Binary Search Trees **Operations** **Performance**

Dictionary


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Dictionary

1. The dictionary ADT
2. Implementations via trees
3. Implementation via lists (skip lists) or tables (hash tables)
4. External searching via B-trees and their variants
5. Trees for higher-dimensional data

Discussions: Dictionary ADT

Possible Implementations **Remarks**

Discussions: Implementation via balanced binary search trees

AVL Trees

Splay Trees

Discussions: Implementation via lists or hash tables

Skip Lists

Hash Tables

Discussions: Hash tables: Collision handling

Hash Tables:

Collision Resolving Strategy	**Remarks**

Discussions: External searching and B-trees

External searching

B-trees and variants

Discussions: Search trees for Higher-dimensional data

KD Trees

Key Features

Graphs and Algorithms I

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Graphs and basic algorithms

$G = (V, E)$

1. Representation: directed and undirected graphs
2. Breadth-first search
3. Depth-first search

Discussions: Adjacency matrix and adjacency list

Adjacency Matrix

Adjacency List

Discussions: Introduction to graph algorithms

Pseudocode **Remarks**

Discussions: Breadth-first search

Data Structures Used

Additional Remarks

Discussions: Using breadth-first search

Graph Properties **Remarks**

Discussions: Depth-first search

Data Structures Used

Additional Remarks

Graphs and Algorithms II

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Graphs algorithms

1. More on depth-first search
2. Single-source shortest path algorithm: Dijkstra and Bellman-Ford
3. All-pairs shortest-path algorithms: Floyd-Warshall algorithms

Discussions: Using depth-first search I

Graph Properties **Remarks**

Discussions: Using depth-first search II

Graph Properties **Remarks**

Discussions: Dijkstra algorithm I (Ideas)

Key Ideas **Remarks**

Discussions: Dijkstra algorithm II (Implementation)

Key Ideas

Remarks

Discussions: Bellman-Ford algorithms

Key Ideas

Remarks

Discussions: Floyd-Warshall algorithm

Key Ideas

Remarks

Algorithms Design Paradigm

Algorithm design paradigm

1. Divide-and-conquer
2. Dynamic programming
3. Greedy methods

Discussions: Divide-and-conquer I

Example **Ideas**

Discussions: Divide-and-conquer II

Example **Ideas**

Matrix chain multiplication

Problem Description **Remarks**

Dynamic programming: Matrix chain multiplication as key example

Recipe **Formulation**

Dynamic programming: Other examples

Example	Ideas

Greedy methods: Examples

Example **Ideas**

Data Compression and Memory Management

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Data compression and memory management

1. Data compression: Huffman coding; LZ77 and LZW
2. Memory management:
   - 2.1 Sequential fit methods
   - 2.2 Buddy system
   - 2.3 Garbage collection; smart pointers

Discussion: Huffman coding I

Problem Description

Remarks

Discussion: Huffman coding II

Problem Description

Remarks

Discussion: LZ77 and LZW

Algorithm	**Remarks**

Discussion: Memory management

Algorithm	**Remarks**

Discussion: Garbage collection and smart pointers

Problem

Remarks

Question

Question In no more than two pages (11- to12-point font printed on letter-size paper), summarize the main topics as presented in the course review this week (week 10).

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