Data Structures and Algorithms

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1 Introduction

These seminar notes contain my overview of the Data Structures and Algorithms course held at University of Bucharest. Because the course is based on heavy theoretic lectures, I tried a more practical approach to present some of the notions by discussing problems which arise natural from the main course.

Most of the problems come from a romanian website specialized on programming contests as well as codeforces or topcoder [1–3]. Of course, there are more interesting problems to tackle, but unfortunately I limit to the course material although sometimes I will talk about some ad-hoc problems.

2 Seminar I

Synthesise first 2 courses:

- Basic notions of time and memory complexity.
- Stacks and Queues.

2.1 Sketch

What is an algorithm? How can we measure the time complexity of a program? Examples (Choosing every pair of elements and erathosthene sieve). Introduction to stacks and queues. Details about their implementation and a short tutorial in STL. Can also talk about circular queues and double ended queues.

2.2 Partial Sums without subtracting

2.3 Checking if an expression has brackets in right order

2.4 Emulate a queue using 2 stacks

2.5 Editor [4]

2.6 Alee [5]

2.7 Trompeta [6]

Given N digits, find the maximum number with K digits such that the digits preserve the initial order.

2.8 Tsunami [7]

Given a matrix NxM with digits less than a value $K(<= 10)$. Find the number of cells with value less than a threshold $T(T <= K)$ such that when you start from 0 you always go up to digits $<= T$.

2.9 Add or Multiply

Take a number X. You can add, subtract, multiply it by numbers in a set S. Find the shortest number of steps required to reach from X to Y.

2.10 Take-Out [8]

N blocks, each black or white. You can remove at a time k white blocks and 1 black block such that there is no gap between the removed blocks.

2.11 Devices

You are given a row of n devices, each consuming some subset of k¡=8 different resources when turned on, and producing some amount of energy when turned on. For each l from 1 to n you need to find the smallest r such that it's possible to turn on some devices from the segment [l;r] such that no two devices turned on consume the same resource, and that the total energy of the devices turned on is at least z [9].

3 Seminar II

- Divide and conquer, merge-sort, estimating complexity

3.1 Inv [10]

3.2 Stergeri [11]

3.3 Muzeu [12]

3.4 Binar [13]

4 Seminar III

Binary search. Fast exponentiation. K'th element. Time complexity proofs (at least sketches).

4.1 Classic Task [14]

4.2 Nrtri [15]

4.3 Sdo [16]

As a further challenge, consider that you can't store $O(N)$ elements. Can you do dynamic medians?

4.4 Loto [17]

5 Seminar IV

Heaps. Binary Heaps. Fibonacci Heaps.

Basic heap operations (Insert, Extract-Min, Merge).

Time, space complexity analysis. Heap reconstruction in $O(N)$.

5.1 Sdo [16]

Can you find the median using heaps? Can you do this dinamically?

5.2 Merge K lists [18]

You have K sorted arrays. Can you merge them quickly?

5.3 Sort using heaps

Classic sort algorithm, this time using heaps. Almost sorted list, can you sort it more efficiently than classic?

6 Back-up problems

6.1 Secv6 [19]

6.2 Dynamic GCD [20]

6.3 Matrice 2 [21]

6.4 Cabane [22]

6.5 Minim2 [23]

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