COMP20007 Design of Algorithms

Week 2 Workshop

Tutorial

Welcome to the first COMP20007 tutorial. Introduce yourself to your peers, and work through the following exercises together.

Reminder: Big O notation Recall from prerequisite subjects that big O notation allows us to easily describe and compare algorithm performance. Algorithms in the class O(n) take time linear in the size of their input. $O(\log n)$ algorithms run in time proportional to the logarithm of their input, (increasing by the same amount whenever their input doubles in size). O(1) algorithms run in 'constant time' (a fixed amount of time, independent of their input size). We'll have more to say about big O notation this semester, but these basics will help with today's tutorial exercises.

- 1. Arrays Describe how you could perform the following operations on (i) sorted and (ii) unsorted arrays, and decide if they are O(1), $O(\log n)$, or O(n), where n is the number of elements initially in the array. Assume that there is no need to change the size of the array to complete each operation.
 - Inserting a new element
 - Searching for a specified element
- Deleting the final element
- Deleting a specified element
- 2. Linked lists Describe how you could perform the following operations on (i) singly-linked and (ii) doubly-linked lists, and decide if they are O(1), $O(\log n)$, or O(n), where n is the number of elements initially in the linked list. Assume that the lists need to keep track of their final element.
 - Inserting an element at the start of the list
- Deleting an element from the start of the list
- Inserting an element at the end of the list
- Deleting an element from the end of the list
- 3. Stacks A stack is a collection where elements are removed in the reverse of the order they were inserted; the first element added is the last to be removed (much like a stack of books or plates). A stack provides two basic operations: push (to add a new element) and pop (to remove and return the top element). Describe how to implement these operations using
 - (i) An unsorted array

- (ii) A singly-linked list
- **4. Queues** A standard queue is a collection where elements are removed in the order they were inserted; the first element added is the first to be removed (just like lining up to use an ATM). A standard queue provides two basic operations: **enqueue** (to add an element to the end of the queue) and **dequeue** (to remove the element from the front of the queue). Describe how to implement these operations using
 - (i) An unsorted array

(ii) A singly-linked list

Can we perform these operations in constant time?

5. Bonus problem (optional) Stacks and queues are examples of *abstract data types*. Their behaviour is defined independently of their implementation — whether they are built using arrays, linked lists, or something else entirely.

If you have access only to stacks and stack operations, can you faithfully implement a queue? How about the other way around? You may assume that your stacks and queues also come with a size operation, which returns the number of elements currently stored.

Computer Lab

The computer labs in this subject will present a number of C programming problems. These problems will reinforce and extend the C programming skills introduced in Foundations of Algorithms, allow us to apply the algorithms and data structures introduced in this course, and help with the C programming required for the assignments.

There's a C Programming Refresher document on the LMS if you need some help getting up to speed.

1. Hello, World! Create a new file called hello.c in your favourite text editor (if you're looking for nice text editors Atom, Visual Studio Code are popular choices; you could also try vim if you're up for a challenge).

Write a simple C program which prints Hello, World!. You can compile the program using gcc:

```
$ gcc -Wall hello.c -o hello
```

This will create an executable file called hello (or hello.exe on Windows). You can then run your program with:

```
$ ./hello # On Linux or Mac OS X, or
$ ./hello.exe # On Windows
```

2. Are we having fun(ctions) yet? Download the functions.c file from the LMS which provides some function prototypes and testing code. It's your job to implement the functions: product(), print_sum(), increase_by_k(), max_in_array() and my_strlen().

You might need to go back and look at some of the content from Foundations of Algorithms, including functions, pointers, arrays and strings. The *C Programming Refresher* on the LMS might be a good place to start.

Compile and run your program to confirm that your implementations are correct.

3. Dynamically Resizing Arrays. Write a C program that utilises dynamically resizing arrays (*i.e.*, arrays created using malloc and resized using realloc) to store an unspecified number of Student IDs for a class enrolment list.

You should initially allocate enough space for 4 Student IDs, and each time the array runs out of capacity you should double the size using realloc.

The program's behaviour should be as follows:

```
$ ./class_list
Enter the Student IDs for the class list, followed by an empty line:
123456
770660
345345
1222333
400500
123123
The IDs for the students in the class are:
123456, 770660, 345345, 1222333, 400500, 123123
The array contains 6 items, and has a capacity of 8.
```

Remember to free all the memory you have allocated. You might need to look up the man pages for scanf, malloc, realloc, assert and free.