Welcome 😊

Introduction of Staffs

Lecturer:
Dr Steven Halim
(call me by my name)

TAs (there are many):
See CS2010 private IVLE
Outline

Some course administration:

• The IT tools used in this module:
  – VisuAlgo: Visualization/animation tool and Online Quiz tool,
  – My own private IVLE with leaderboard (will also talk about PSes),
  – Online Judge system (Mooshak)

• The module itself

• CP3 book sales (with help of TAs)

CS1020 Quick Review + Comparison with CS2010

• Preview of VisuAlgo Online Quiz 0 (worth 1%)

Problem Solving Paradigms in the context of CS2010

• Complete Search, Divide & Conquer, Greedy, and Dynamic Programming
Introducing VisuAlgo

Our own data structures & algorithms visualization:

http://visualgo.net

(still an evolving project)

VisuAlgo will be very heavily used in CS2010 lectures, tutorials, and lab demos (bring your laptop/tablet*)

We will NOT use ‘static’ PowerPoint slides 😊
VisuAlgo Online Quiz Tool

1+4+5 = 10% of your grade will be machine-graded
http://visualgo.net/training.html
http://visualgo.net/test.html

Make VisuAlgo as your personal tutor 😊
Bookmark the base URL; tell the world it exists!
Private IVLE with “Gamification”

URL: http://www.comp.nus.edu.sg/~stevenha/cs2010.html#leaderboard

Check Your Email! (uid: your matric no; pwd: 8 random chars*, keep it for one semester)
There are 6* Problem Sets (PSes) in CS2010

- All of them are “babies related” 😊, in chronological order, and use real-life examples (some are a bit exaggerated)
- Each 6 normal PSes has the same weightage (100^ EXP points)
- There will also be 1 bonus PS (of smaller weightage #AC/12* 100 EXP points, team of 3 CS2010 students, see last slide)
  - This AY, it is tied with 2015 ACM ICPC Singapore Preliminary Contest
  - Useful to catch up if you lose some marks in some early PSes or as buffer for some future PSes
- 30 EXP = 1 level = 1% in PS component of this module
  - The maximum level is level 19, there is no level 20, levels are integers
  - There is a 2x30 = 60 EXP gap between level 18 and level 19 :O
  - The average is expected to be around level ~17
(Bi) Weekly PS (2)

Rules for (Bi) Weekly PS:

• Collaboration is strongly encouraged, but you have to write the solution (i.e. the Java code) by yourself!

• Posting algorithm/data structure ideas to Facebook group is strongly encouraged, but you can never send your Java code to anyone to before deadline, even if it is a “buggy” one!
  – You have to write and debug your own Java code!
  – Severe penalty for those who breach this rule
  – Looking at your seniors’ code is considered as plagiarism
  – All submissions to the online judging server is recorded! Do NOT submit someone else’s code using your account!
  – We have installed automatic plagiarism checker, be careful!
(Bi)Weekly PS (3)

PSes are the core of CS2010

• Most likely you will spend many hours (depending on your aim) discussing and implementing the solutions
  – It is designed as one “simple” problem with “subtasks” with *gradual* level of difficulty
    • The easier subtask just require CS1010-CS1020 knowledge
    • Most subtasks definitely require CS2010 knowledge
    • The last subtask (usually the R-option) require perhaps CS3230/CS3233 knowledge

• The ideas (not the Java code) that can solve Subtask 1-2 of each PS will be discussed during the tutorial sessions 😊
  – So, you can score up to 25-50 (out of 100) marks by understanding what is discussed in the tutorial and then implementing it
(Bi)Weekly PS (4)

PSes are the core of CS2010 (continued)

• The implementation of the required technique (but not the actual solution) that can be used to solve parts of the harder subtasks will be discussed during the lab demos
  – You can score up to 50-75 (out of 100) marks by understanding what your Lab TA is trying to tell you during his/her lab demo

• The last subtask and/or the R-option subtask (if exists) of each PS is/are designed for those who are aiming to get A/A+ in this module... they are either difficult or tedious
  – If this is your aim, you may end up spending hours to solve this
  – The majority of you do not have to attempt this every week :O
  – No bonus mark for solving R-option subtask for non CS2010R student
(Bi)Weekly PS (5)

In picture:

Estimated efforts needed (in hours)

- 3 hours
- 10 hours

Estimated efforts needed:

- Subtask1/2 (up to 40 marks)
- Subtask2/3 (up to 70 marks)
- Last 1 or 2 Subtask(s) (up to 100 marks)

Ideas discussed during lab demos. You are on track if you can consistently get to this point for every PS.

Ideas will be discussed openly in tutorial session.

R
(Bi)Weekly PS (6)

Expected workload

Extreme

High

PS1

PS2® PSB®

PS3

PS4

PS5®

PS6®

CS2010 B-/B level
CS2010R or CS2010 A/A+ level

For your other modules midtests 😊

For CS2010 Quiz 1 😊
Online Judge System for PS

Our Online Judge System:
http://algorithmics.comp.nus.edu.sg/~mooshak

I will give a brief demo using PS0 and explain of the pros/cons of using this ‘strict’ system

your CS2010 account: (uid=matric number/special pwd)
has been emailed to you on ?? August 2015

CS2010 account can be used to access VisuAlgo Online Quiz, Steven’s Private IVLE, and Mooshak (PS)
THE MODULE...
Typical Class Profile (CS2010 in S1)

There are a few 3rd/4th year CEG, SCI, and Exchange students in this class who do not have to take this course (but you take it).

If a 2nd year SoC student failed in CS1010/CS1020 before, they will not reach CS2010 in S1 yet.

~300 SoC students

~40 have taken CS2020 last semester

New this Sem: You are the first batch who went through NUS Grade Free First Semester

And from these remaining students, about half have chosen IS and do not need to take CS2010 in S1.
How to get B-/B grade in CS2010

Very simple

Just do the minimum requirements
How to get B+/A- grade in CS2010

Do all those required for B-/B grade

Improve your mathematics proficiency
(One indicator is your performance on CS1231 or MA1100)

Summary: Occasionally able to perform better than the published average scores
How to get A/A+ grade in CS2010

Summary: Do everything that is graded with near perfect score...

Has to be in the leader board
http://www.comp.nus.edu.sg/~stevenha/cs2010.html#leaderboard

A/A+ students in CS2010 are invited to take Steven’s CS3233 course in Sem2 AY 2015/2016 and/or to be Steven’s TA for future CS2010
For those who struggle with CS1010/CS1231/CS1020 series

Come to Steven personally and I will try to make some extra arrangements for you
• Several Saturday help sessions are in the pipeline

Note that you are now at University level
• I will not beg you to come to me, but will only help you if you approach me
• The earlier the better...
Social Media Feature

We have a Facebook page!

https://www.facebook.com/groups/241724769269875

I drop IVLE discussion forum for a reason*...

Join now (if you don’t have FB account**, register)!
(I will give you all one minute)
Lab and Tutorial Groups Updates

See Private IVLE for the current plan
CP3 Book Sales

Not compulsory (actually a CS3233 text book)

Contains about ~70% of my algorithmic knowledge so far
• Useful to tackle the last subtask of each PS and to answer some tricky questions during Quiz1/2/Final (maximum 20-25% per each test)

Local sales at **25 SGD/copy** (30 last year)
• I have ~50 copies for Lecture 01, many more copies in my office

Alternative option: Borrow @ CL
• RBR (Reserved Books/Readings) QA76.6 Hal 2013
5 minutes break, and then...

**CS1020 (AND CS1231) REVIEW WITH HELP OF VISUALGO**
About My Lecture Style

Heavy usage of technology:
VisuAlgo and its Online Quiz for in-class pop quizzes

If you need verbal clarifications during lecture...

• Please wait until lecture breaks or after lecture
• Alternative: Post questions in the FB group
  – Remember, we do not have IVLE discussion forum this time
CS1020 – OOP

Object Oriented Programming (OOP)

class BankAccount {
    private int Balance;
    public BankAccount();
    public void Deposit(int Amount);
    public void Withdraw(int Amount);
    public int CheckBalance();
}

We will use OOP principles in our CS2010 PSes
• e.g. We use “IntegerScanner”, “IntegerPair”, etc in CS2010
CS1020 – Basic Algorithm Analysis

Big O notation, the $O(g(n))$ stuffs, e.g.

```java
    sum = 0;
    for (int i = 0; i < n; i++)
        sum += A[i];
    // is an $O(n)$ algorithm
```

In CS2010, we will

• Extensively use this algorithm analysis
• Learn a few more advanced algorithm analysis skills
Data Structure is a way to store and organize data
• We will frequently abbreviate it as DS

A good DS is needed to support efficient:
• Insertions: add a new item into the DS
• Searches: is item X inside the DS or not?
• Deletions: remove a certain item out from the DS
• Queries: how many items is the DS?, what is the min item in the DS?
• Updates: combination of (or a more efficient form than) “delete the old item” and “insert the new item”

Different situations may require different DS
CS1020 – Linear Data Structures (2)

Linear DSes that you learned in CS1020:
• Items listed in left-to-right (or top-to-bottom) order
  – Array (fixed size)/Vector (resizeable)
  – Linked List
  – Stack: Last In First Out (LIFO)
  – Queue: First In First Out (FIFO)

You will learn one more in CS2010 (only in Sem1):
• Lightweight array of Boolean (Bit manipulation)

Then, you will learn the non-linear DSes:
• Binary Search Tree, (Binary) Heap, Union Find, Graph
CS1020 – Sorting

What you learn in CS1020:
• O(N^2) Selection Sort, Bubble sort, Insertion sort
• O(N log N) Merge sort
• Expected O(N log N) Quick sort if the pivot is randomized
  – Can run in O(N^2) otherwise (this is what you learned in CS1020)

In CS2010:
• If not explicitly stated, you can use Java library functions, e.g. Collections.sort for all your sorting needs
• We will learn more sorting algorithms: Heap Sort, BST Sort
Sorting Visualization
CS1020 – Recursion

In CS1020, you may have learned these examples:

• “Countdown”
• Factorial
• Printing a linked list in reverse order
• Towers of Hanoi
• N choose K
• Recursive binary search
• Fibonacci

In CS2010, we will see much more recursion
Recursion Tree/DAG Visualization
CS1020 – Hashing

Concepts that you learn:

• Direct Addressing Table
• Creating good Hash Function
• Handling collisions: Birthday paradox
  – Separate chaining
  – Linear probing, quadratic probing, double hashing

We do not relearn hashing again in CS2010

• But you may have to contrast and compare it with BST later
Hash Table
Let’s Review CS1020!

• VisuAlgo Online Quiz 0 (1%)
  – Non zero weightage, so people try
  – Almost all of you will get this 1%, if you practice 😊
  – [http://visualgo.net/training.html](http://visualgo.net/training.html), select CS1020 topic, hard setting, 4 questions, 5 minutes
  – Once you are comfortable, go to [http://visualgo.net/test.html](http://visualgo.net/test.html) to claim your 1% (also hard setting, 20 questions, 20 minutes)
  – Test mode for Online Quiz 0 opens from XX to YY (TBA), one attempt only, so practice first
Another relevant module for CS2010 is CS1231

• But CS1231 is not a pre-req of CS2010

• Relevant stuffs are:
  – Discrete structures: Graphs and Trees
  – Proofs (simpler form)

In CS2010, we will see all these discrete structures practically throughout the semester

• That’s it, lots of trees and graphs and proofs (simpler form)
Source:
- Competitive Programming 3, Chapter 3 (overview)
- Introduction to Algorithms, 2nd ed, Chapter 7 and 15-16
This is what we will learn in CS2010 😊
Complete Search

Given an integer array \( A = \{10, 7, 3, 5, 8, 2, 9\} \), \( n = 7 \)
Find the largest and the smallest element of \( A \)!
Divide and Conquer

Given an integer array $A = \{10, 7, 3, 5, 8, 2, 9, \ldots\}$, but now $n = 100000$ items

What is the $12345^{\text{th}}$ smallest item in $A$?

Is the previous Complete Search algorithm suitable?
Greedy

Given an integer array $A = \{10, 7, 3, 5, 8, 2, 9, \ldots\}$

$n$ is still 100000 items

Find the largest gap $g$ such that $x, y \in A$ and $g = |x - y|$
Dynamic Programming

Given an integer array \( A = \{10, 7, 3, 5, 8, 2, 9, \ldots\} \)
but now \( n = 1000 \) items

What is the **longest subsequence** of \( A \) that if viewed from left to right is always non decreasing?

- \( \{3, 5, 8\} \) is a subsequence, and non decreasing
- \( \{3, 5, 8, 2\} \) is also a subsequence, but \( 8 \rightarrow 2 \) is decreasing
- \( \{3, 5, 8, 9\} \) is the longest so far (ignoring the ‘…’)

Solution will be discussed in Lecture 10 

Time complexity: \( O(n^2) \), but it is possible to get \( O(n \log k) \)
In the Context of CS2010 (1)

Lecture 02

- A **Divide and Conquer** principle in Data Structure
- Heap DS and operations on it

Lecture 03-04

- Another **Divide and Conquer** principle in Data Structure
- Binary Search Tree (BST) and operations on it
- Balanced BST: Adelson-Velskii Landis (AVL) Tree
In the Context of CS2010 (2)

Lecture 05

• A few more Data Structures
  – Union-Find Data Structure
  – Bitmask Data Structure
  – Basic Graph Data Structure

• (Quiz 1 is up to here)

Lecture 06

• Graph Traversal
  – Breadth-First and Depth-First Search
  – Their applications (usually classified as Complete Search)
In the Context of CS2010 (3)

Lecture 07
• Minimum Spanning Tree (MST)
  – Prim’s and Kruskal’s are both Greedy algorithms

Lecture 08-09:
• Single-Source Shortest Paths (SSSP)
  – Bellman Ford’s, Dynamic Programming
  – Dijkstra’s, Greedy algorithm
• (Quiz 2 is up to here)
In the Context of CS2010 (4)

Lecture 10-11-12
• Algorithms on DAG
• Traveling Salesman
• All-Pairs Shortest Paths
  – All use Dynamic Programming
• (Final exam is up to here)

Lecture 13
• Mystery Lecture, let it be a mysterious one for now 😊
That’s all for today

We will gear up for the first main topic of CS2010
• ADT Priority Queue and Binary Heap Data Structure

To do list at home:
• Review CS1020 material about Array, Linked List, Queue

PS: One advertisement in the last slide
NUS ACM-ICPC 2015 @ SG/NUS