CS 2022 : DATA STRUCTURES & ALGORITHMS

Lecture 1: Introduction

Malaka Walpola

Outline

- Class Details
- Learning Outcomes
- Introduction
- Insertion Sort
- Bubble Sort

Class Details

CS 2022 : Data Structures & Algorithms

- Credits: 2.5 (GPA)
- Pre-requisites : None
- Course Objective:
  - Provide an understanding of how to approach problem solving in computer science

CS 2022 : Data Structures & Algorithms

- Lecturers: Malaka Walpola
  - Contact information
    - Room: Inside the staff area of the CSE dept.
    - E-mail: malaka@cse.mrt.ac.lk
    - Phone: 0718661380

CS 2022 : Data Structures & Algorithms

- Hours/ Week:
  - Lectures – 2 hrs
    - Thursday 9.15 - 11.15
  - Tutorial/Lab
    - Monday 3.15 to 6.15
  - Reading the Book, Self Study & Homework: 5 hrs (will depend on individuals)

Learning Outcomes

- After completing this module, students should be able to
  - analyze the complexity of algorithms
  - implement and use common data structures
  - select appropriate data structures and algorithms for a given situation
  - apply basic algorithm design techniques for a given situation

Course Outline

- Complexity Analysis of Algorithms
- Recursion
- Searching
- Sorting
- Basic Algorithm Design Techniques
  - Divide-and-conquer
  - Greedy approach
  - Dynamic programming

Course Outline

- Basic Data Structures and Operations on Them
  - Arrays, Linked lists, Queues, Stacks
  - Sets
  - Trees
  - Hash tables
  - Graphs
- Introduction to NP-Completeness

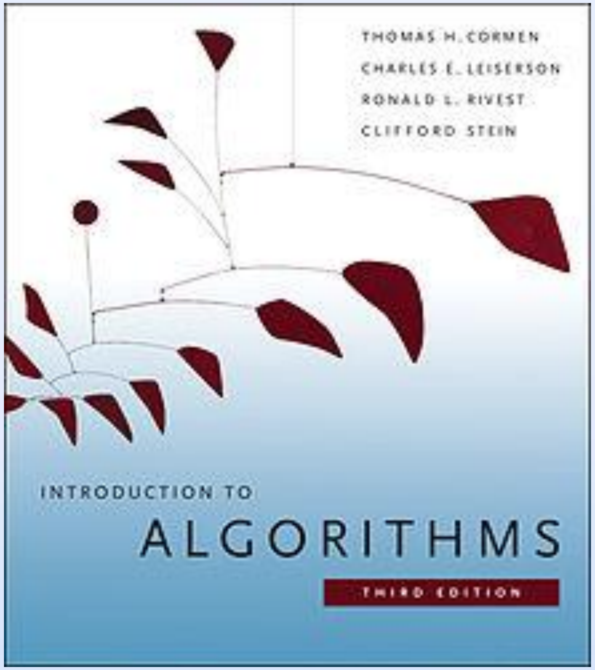
* Not in Order

Method of Assessment

- Exam – 60% (35% to Pass)
  - 2 hour
  - Closed book
  - Answer all
  - Will have short answer/multiple choice questions
- Continuous Assessments – 40% (35% to Pass)
  - Labs – 60%
  - Mid semester exam - 40%

Recommended Text Books

- Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, *Introduction to Algorithms*, 3rd Ed. Cambridge, MA, MIT Press, 2009.



Class Rules

- Be Respectful and Responsible
  - No talking among yourselves
  - No cell phones
- Be Organized and Follow Directions
- Be Prepared
  - If you miss a lecture, it is your responsibility to makeup
  - No makeup labs/tutorial slots

Class Rules

- Take Home CA Must Be Your Own Work
  - It will help you understand the material
  - Cite all references
  - We may be using plagiarism detection tools
- Homework and In-class activities are Individual Work
  - No peeking, copying, talking during In-class activities
  - Don’t let someone else copy from you as well
- All course contents will be provided through the course Moodle page

EXPECTATIONS

- All the students are required to read the assigned sections of the book
  - Please keep up with the reading
  - In-class activities and homework will assume that you have done this.
- All the students are expected to actively participate in the in-class activities

Questions or Concerns?

Introduction

Learning Outcomes

- After successfully studying contents covered in this lecture, students should be able to,
  - explain what an algorithm is and express an algorithm using pseudo code of flowcharts
  - explain the insertion sort, bubble sort & optimized versions of bubble sort

Introduction

- What is an Algorithm?
  - Well defined procedure
  - Takes some inputs
  - Produce some outputs
- An algorithm is a ***step-by-step*** method of ***solving a computational task***
- Why Do We Study Algorithms?
  - To make understanding and solving problems simple
  - To solve problems in the BEST way

Sample Problems

- Searching the Web for the Stanford University Honor Code
- Calculating the Fourier Transform of a Signal
- Designing a PCB Layout for a Circuit
- Sorting a List of Names
- Calculating Best Path from Colombo to Anuradhapura

Sample Problems

- Searching the Web for the *Stanford University Honor Code*
- Calculating Best Path from *Colombo* to *Anuradhapura*
- Calculating the Fourier Transform of a Signal
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Computational Task

- A computational task is not just a "single" task such as
  - "Is 3962431 prime ?"
  - "What is 37487*2371 ?"
- A computational task is a whole family of "similar" tasks with varying INPUT, such as
  - "Given a whole number A, is A prime?"
  - "Given 2 numbers x and y, what is x times y?"

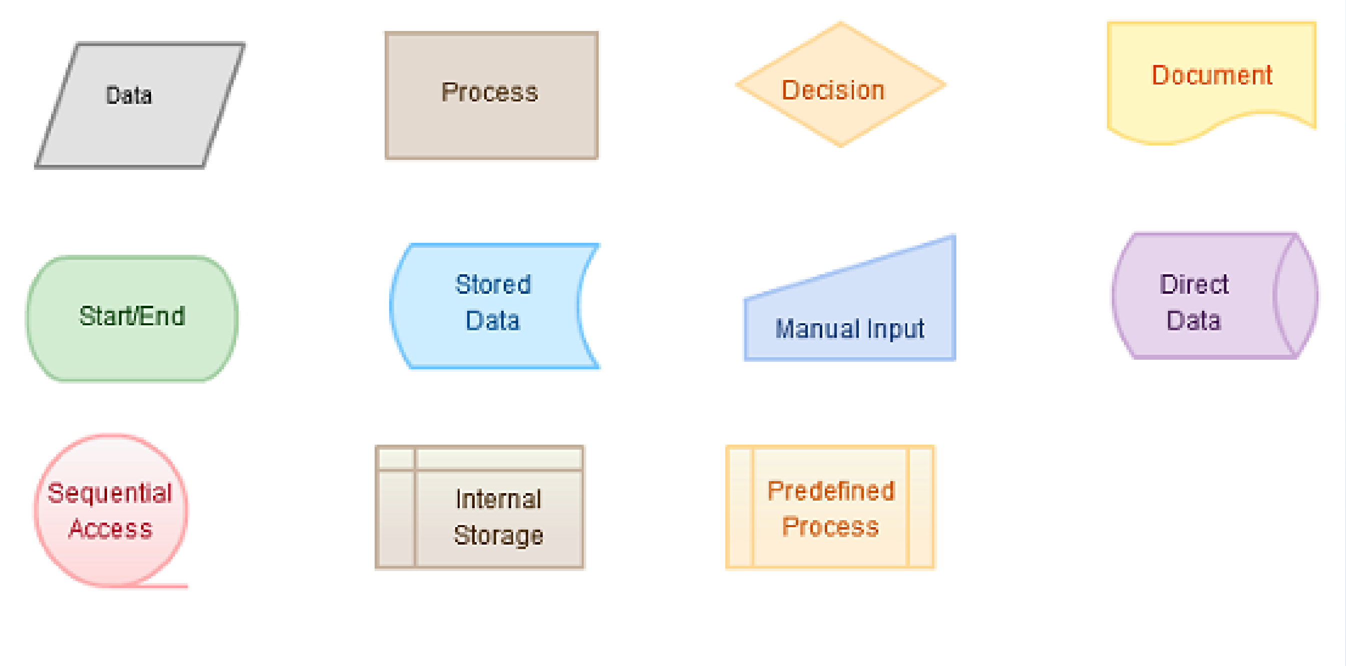
Specifying Algorithms

- Listing the Steps
- Flowcharts
- Pseudo Code
- Program Listing

- Class Activity
  - Specify an algorithm to add all the numbers in an array/list.

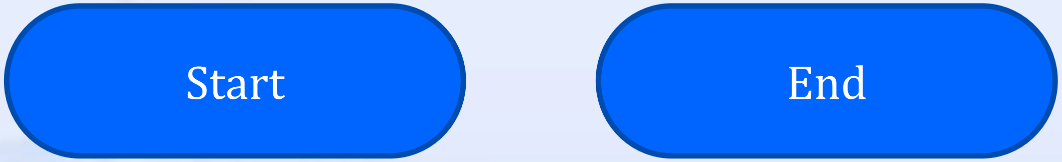
Flowcharts

- A diagram that show the "flow of control" of an algorithm/a program
- Flowchart symbols



Flowchart Symbols

- Terminals
  - Represents the stat or end of the process
  - Represented by rounded rectangles

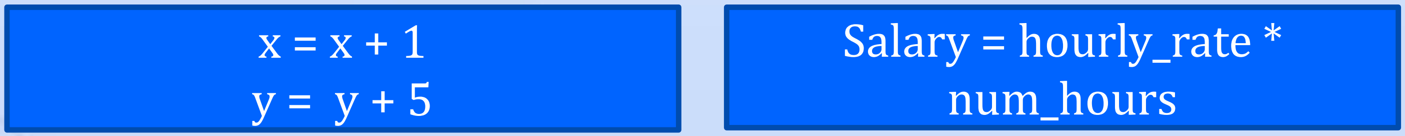


- Input/output Data
  - Represented by parallelograms
  - Indicate an input or output operation

Flowchart Symbols

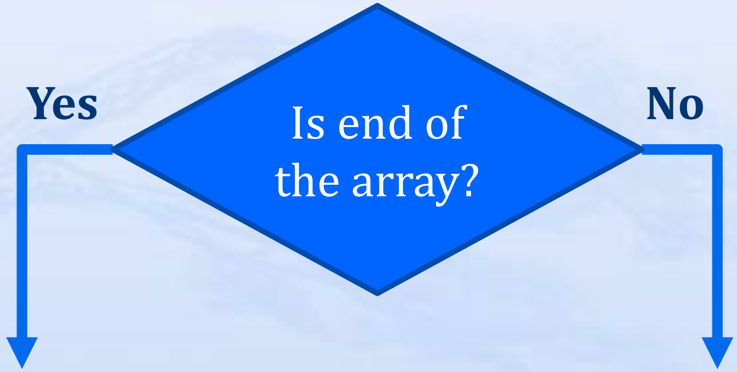
- Stored Data
  - Represented by rectangles
  - Indicates a process such as a mathematical computation or variable assignment

- Processing
  - Represented by rectangles
  - Indicates a process such as a mathematical computation or variable assignment



Flowchart Symbols

- Decision
  - Represented by diamond shape
  - Indicates different paths of execution/choices the program can take



Insertion Sort

The Sorting Problem

- Input:
  - A sequence of *n* numbers $\langle a_1, a_2, a_3, \ldots., a_n \rangle$
- Output:
  - A permutation (ordering) $\langle a'_1, a'_2, a'_3, \ldots., a'_n \rangle$ of the input sequence such that $a'_1 \leq a'_2 \leq a'_3 \leq \ldots. \leq a'_n$
- A More General Version
  - Input:
  - Output:

*Source [1]

Insertion Sort

- Suitable for Sorting Small Number of Elements
- The Idea
  - Remove an element from input and insert it in proper location

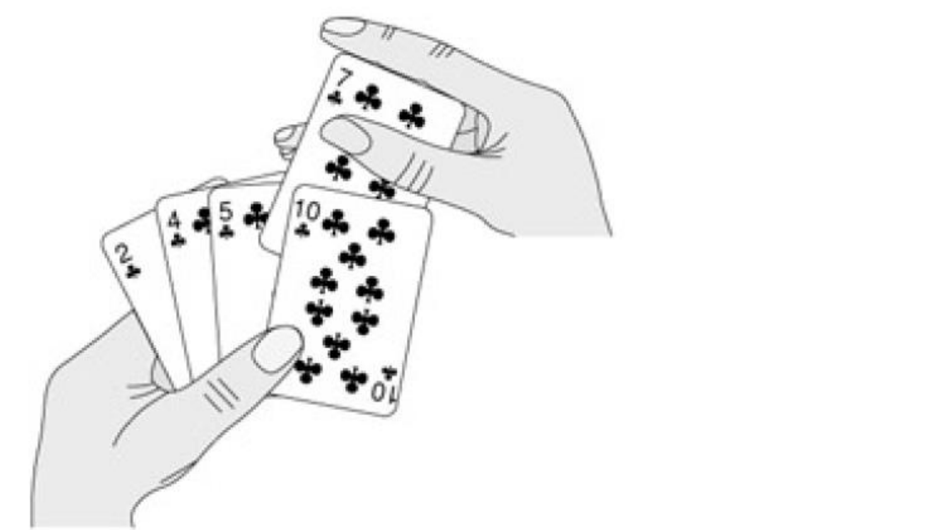


Figure 2.1: Sorting a hand of cards using insertion sort.

Image taken from [1]

Insertion Sort

- The Idea

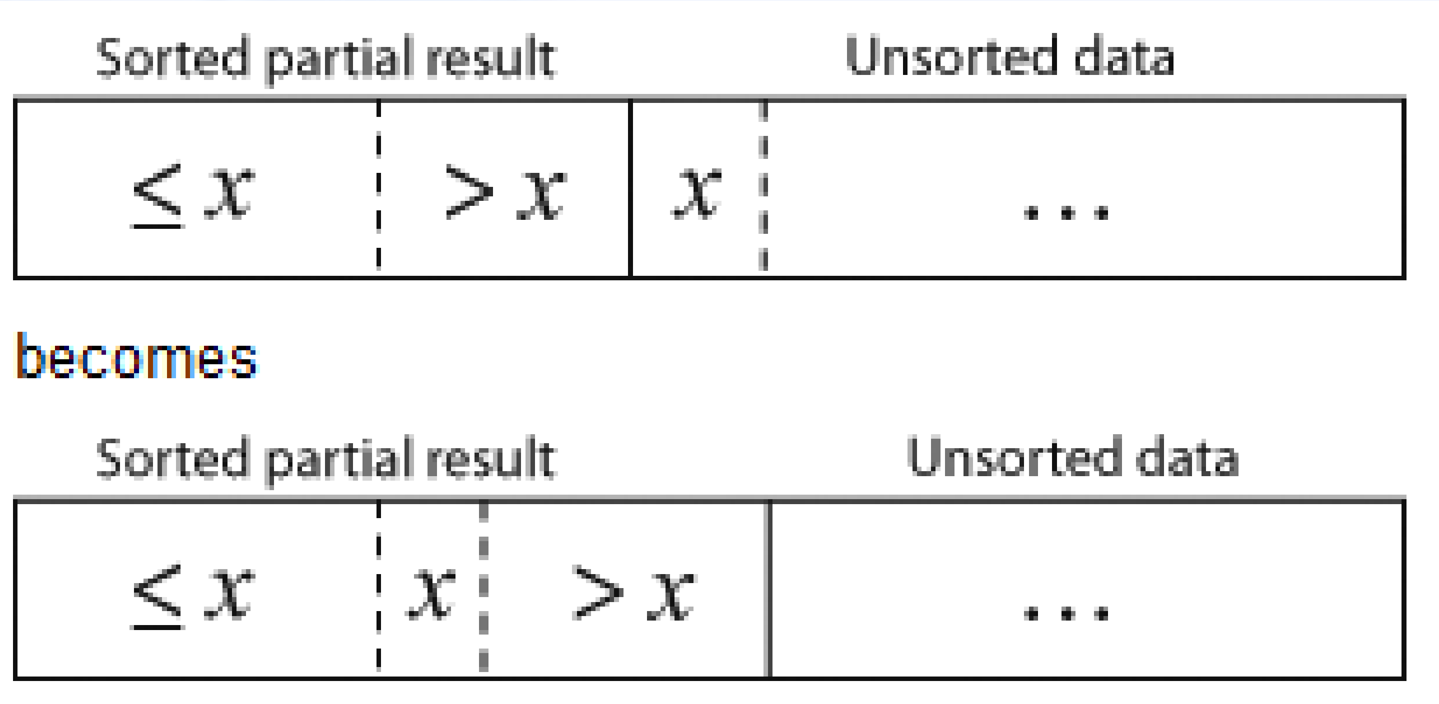


Image taken from [3]

The Algorithm

```
INSERTION-SORT(A)
for j = 2 to A.length
  key = A[j]
  //Insert A[j] into the sorted sequence A[1, ……, j-1].
  i = j-1
  while i > 0 and A[i] > key
      A[i+1] = A[i]
      i = i-1
  A[i+1] = key
```

Bubble Sort

- The Idea:
  - Bubble up the largest(smallest) element to the bottom(top) of the list in each iteration
  - Repeatedly step through the list
    - Compare each pair of adjacent items
    - Swap them if they are in the wrong order
    - Repeated until no swaps are needed, which indicates that the list is sorted

The Algorithm (Homework)

```
BUBBLE-SORT(A)
do
    swapped = false
      for i = 2 to A.length
        if A[i-1] > A[i]
          temp = A[i]
          A[i] = A[i-1]
          A[i-1] = temp
          swapped = true
while swapped
```

References

[1] T.H. Cormen, C.E. Leiserson, R.L. Rivest and C. Stein, *Introduction to Algorithms*, 3rd Ed. Cambridge, MA, MIT Press, 2009.

[2] Wikipedia , "Insertion sort", Oct. 09, 2012. [Online]. http://en.wikipedia.org/wiki/Insertion_sort. [Accessed: Oct. 22, 2012].

[3] Wikipedia , "Bubble sort", Oct. 17, 2012. [Online]. http://en.wikipedia.org/wiki/Bubble_sort. [Accessed: Oct. 22, 2012].

Homework

- Reading for Today's Class
  - Introduction: Chapter 1
  - Insertion Sort: Sections 2.1 & 2.2
  - Bubble Sort: [3]
- For Next Class
  - Asymptotic Notation: Section 3.1