

CSU22011: ALGORITHMS AND DATA STRUCTURES I

Lecture 1: Module Overview & Introduction

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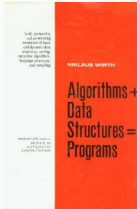


Trinity College Dublin

Coláiste na Tríonóide, Baile Átha Cliath

The University of Dublin

→ **Objective:** learn to solve computational problems **efficiently**



“Algorithms + Data Structures = Programs”

— Niklaus Wirth



→ **Algorithm:** The steps to **correctly** perform a task that answers a **general**¹ computational problem

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- **Algorithm:** The steps to **correctly** perform a task that answers a **general**¹ computational problem
 - What is the median age of all people in Ireland?
 - What is the quickest route from here to the airport?
- **Data Structures:** The ways to store the information needed for the algorithm.
 - Array, Linked List, Hash Table, Binary Tree, etc.

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- must be **efficient**

WHAT IS EFFICIENCY?

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WHAT IS EFFICIENCY?

Established measure: how well the program **scales** to larger inputs

- When I **double** the input size my program takes **the same** time to run on the same computer (*constant running time*).
- When I **double** the input size my program takes **twice** the time to run on the same computer (*linear running time*).
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We also care about **memory needed**:

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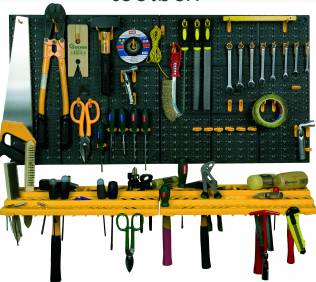
Scalability may some times seems crude but at least allows us to **compare algorithms**

- Learn the most common A&DS that every CS graduate must know.
 - Example algorithms: Merge Sort, Union-Find, Dijkstra's Shortest Path Tree, ...

The Software Engineer's
toolbox

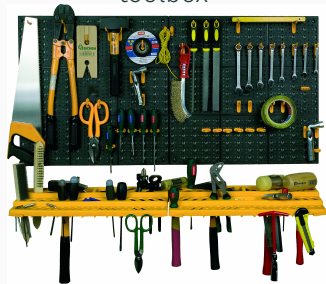


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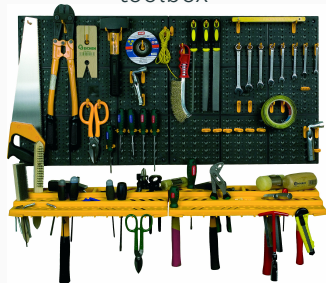
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- Identify which known algorithms/data structures **best fit** specific problems
 - Example: What is the best algorithm for finding the median?
 - It depends:^a QuickSelect, MedianOfMedians, IntroSelect, using SoftHeaps

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- Learn **Abstract Data Types**: interfaces of A&DS

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- Learn **Abstract Data Types**: interfaces of A&DS
- Practice **implementing** A&DS

^a<https://www.quora.com/What-is-the-most-efficient-algorithm-to-find-the-median>

The Computer Scientist's toolbox



- Learn to **evaluate** new algorithms
 - Efficiency: **calculate** the running time and memory usage
 - **how well they scale**
 - **Measuring aspects:** Worst-case, average-case, amortised, experimental performance
 - **Measuring systems:** big-O notation, tilde notation, cost models
- Correctness: **rigorous testing** and some informal correctness arguments (see Unit Testing, test coverage)

CSU22011 LOGISTICS

Primary website: <https://mymodule.tcd.ie>

EXAMPLE PROBLEM

A software engineer was asked to design an algorithm which will input two **unsorted** arrays of integers, **A** (of size N) and **B** (also of size N), and will output **true** when all integers in **A** are present in **B**.

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The engineer came up with **two** alternatives. The first is:

```
boolean isContained1(int[] A, int[] B) {  
    boolean AInB = true;  
    for (int i = 0; i < A.length; i++) {  
        boolean iInB = linearSearch(B, A[i]);  
        AInB = AInB && iInB;  
    }  
    return AInB;  
}
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The second is:

```
boolean isContained2(int[] A, int[] B) {  
    int[] C = new int[B.length];  
    for (int i = 0; i < B.length; i++) { C[i] = B[i] }  
    sort(C); // heapsort  
    boolean AInC = true;  
    for (int i = 0; i < A.length; i++) {  
        boolean iInC = binarySearch(C, A[i]);  
        AInC = AInC && iInC;  
    }  
    return AInC;  
}
```

- (a) Calculate the **worst-case running time** of each of the two implementations.
- (b) For each implementation, how much **extra memory space** is it required to store copies of the elements in **A** and **B**? You should take into account any copies made within the methods **sort**, **linearSearch**, and **binarySearch**.
- (c) Find an implementation which is more efficient than both of the engineer's implementation.

WHY?

<http://www.youtube.com/embed/vSi6YoTPWLw?rel=0&start=8&end=165>

WHY?

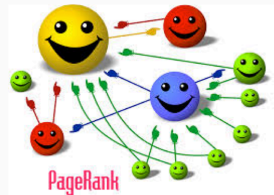
→ To get a technology job
<http://www.careercup.com>



WHY?

→ To create the “New Google”

<http://en.wikipedia.org/wiki/PageRank>



WHY?

→ To make science

<http://ocw.mit.edu/courses/biological-engineering/>

20-482j-foundations-of-algorithms-and-computational-techniques-in

Foundations of Algorithms and Computational Techniques in Systems Biology

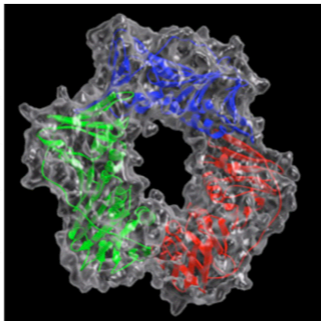
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The role of the Rad checkpoint complex was inferred from the 3-D structure predicted by comparative modeling at Lawrence Livermore National Laboratory. The Rad complex delays cell division to allow time for DNA repair to take place. (Image courtesy of the [U.S. Department of Energy Genomics: GTL Program.](#))

Instructor(s)

Prof. Bruce Tidor

Prof. Jacob White

MIT Course Number

20.482J / 6.581J

As Taught In

Spring 2006

Level

Graduate

Translated Versions

简体字

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WHY?

→ To win big on the stock market

[http://www.theguardian.com/business/2012/oct/21/
superstar-traders-lost-magic](http://www.theguardian.com/business/2012/oct/21/superstar-traders-lost-magic)

One theory for the decline of the superstar trader is the rise of the analytical nerd and computerised algorithmic trading. Schmidt says: "The superstars are confronted with a changing market. The punting around is not working. You now need to be either a traditional long-term stock picker, a very short-term person working on algorithms, or a combination of both. There is no future for guys like Coffey.

→ To rule the world!

[http://www.theguardian.com/science/2013/jul/01/
how-algorithms-rule-world-nsa](http://www.theguardian.com/science/2013/jul/01/how-algorithms-rule-world-nsa)

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How algorithms rule the world

The NSA revelations highlight the role sophisticated algorithms play in sifting through masses of data. But more surprising is their widespread use in our everyday lives. So should we be more wary of their power?

WHY?

→ For fun!

http://en.wikipedia.org/wiki/Tower_of_Hanoi

