The Role of Algorithms in Computing

ITX2010, CSX3003, IT2230

Data Structures and Algorithms, Information Structures

Learning Objectives

Students will be able to:

- Understand what algorithms are

Chapter Outline

1. The Role of Algorithms in Computing
   1) Algorithms
   2) Algorithms as a technology

1) Algorithms
2) Algorithms as a technology

1.1

The Role of Algorithms in Computing

Algorithms

- A computational procedure → that take some input(s) and → return some output(s).
- A tool for solving a computational problem
- Algorithm is correct ← →
  - it finishes (halts) its computing in finite time and
  - It outputs the correct solution

Algorithm	
A computational problem	Sort a sequence of numbers into monotonically increasing order → Sorting problem
Input	A sequence of n numbers < a1, a2, … , an >
Output	A permutation (reordering) < a'1, a'2, … , a'n > when a'1 ≤ a'2 ≤ … ≤ a'n

What kinds of problems are solved?

Algorithms

- Searching
- Manipulation
- Find a shortest path
- Resource allocation
- Topological ordering
- Clustering
- Compression, Encode / Decoding

Data Structures

Algorithms

- A way to store and organize data →in order to facilitate access and modification.
- No single data structure works well for all purposes
  - You should know its strengths and limitations
  - You should use an appropriate data structures →which is an important part of the algorithm design.

Hard Problems

Algorithms

- NP-complete problem → It has no known efficient algorithm
- Ex: Traveling-salesperson problem

As a concrete example, consider a delivery company with a central depot. Each day, it loads up delivery trucks at the depot and sends them around to deliver goods to several addresses. At the end of the day, each truck must end up back at the depot so that it is ready to be loaded for the next day. To reduce costs, the company wants to select an order of delivery stops that yields the lowest overall distance traveled by each truck. This problem is the well-known "traveling-salesperson problem,"

1) Algorithms
2) Algorithms as a technology

1.2

Algorithms as a technology

Algorithms as a technology

- If computers were fast and memory were free, → would you have any reason to study algorithms?
  - Yes #
  - Computer may be fast, but it is not fast because of the computing time.
  - You should choose an appropriate algorithm that spend the optimize time and space

Efficiency

Algorithm as a technology

Issue \ Algorithm	Insertion sort	Merge sort
Running time of sorting n items	$C_1 n^2$	$C_2 n \lg n$
If n=1000 = 10^3 If n=1,000,000 =10^6	≈ 10^3 x 10^3 = 10^6 ≈ 10^6 x 10^6	≈ 10^3 x 10 → 10^4 ≈ 10^6 x 20
	No matter C1 and C2 are, there is always a cross over point beyond which merge sort is faster.	
Given two different computer's specification	• **Fast** computer A executes 10^{10} instructions / seconds	**Slow** computer B execute 10^7 instructions / second
Running time Estimation	If C_1= 2 and n= 10^7, $= \frac{2 \bullet (10^7)^2}{10^{10} \text{ instruction/section}}$ = 20,000 sec. >5.5 hours)	If C_2=50, $= \frac{50 \bullet 10^7 \lg 10^7}{10^7 \text{ instruction/section}}$ $\approx 1{,}163 \text{ sec.} < 20 \text{ minutes}$ #

References

Texts | Integrated Development Environment (IDE)

[1] Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein,, Fourth Edition, The MIT Press, 2022.

[2] https://colab.research.google.com/