Algorithms: Introduction

Algorithm Etymology

- *Algorism* = process of doing arithmetic using Arabic numerals.

- A misperception: *algiros* [painful] + *arithmos* [number].

- True origin: Abu 'Abd Allah Muhammad ibn Musa al-Khwarizm was a famous 9th century Persian textbook author who wrote *Kitab al-jabr wa'l-muqabala*, which evolved into today's high school algebra text.

What is an Algorithm?

Algorithms are the ideas behind computer programs.

An algorithm is the thing which stays the same whether the program is in assembly language running on a supercomputer in New York or running on a cell phone in Kathmandu in Python!
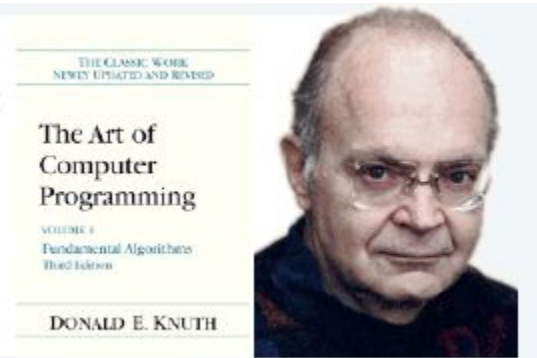
To be interesting, an algorithm has to solve a general, specified problem.

An algorithmic problem is specified by describing the set of instances it must work on, and what desired properties the output must have.

Algorithm Definitions

" *An algorithm is a finite, definite, effective procedure,*

with some input and some output. "

— *Donald Knuth*

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VOLUME 1
Fundamental Algorithms
Third Edition

DONALD E. KNUTH

Why study algorithm?

Internet. Web search, packet routing, distributed file sharing, …
Biology. Human genome project, protein folding, …
Computers. Circuit layout, databases, caching, networking, compilers, …
Computer graphics. Movies, video games, virtual reality, …
Security. Cell phones, e-commerce, voting machines, …
Multimedia. MP3, JPG, DivX, HDTV, face recognition, …
Social networks. Recommendations, news feeds, advertisements, …
Physics. N-body simulation, particle collision simulation, …

Why study algorithm?

- Also, Algorithms are
  - Fundamental for CS
  - Useful
- And also,
  - Algorithms are fun!

Questions to ask in this course!

- Does it work?
- Is it fast?
- Can we do better?

Computational Problems and Algorithms

- A ==computational problem== is a specification of the desired input-output relationship.
- An ==instance of a problem== is all the inputs needed to compute a solution to the problem.
- An ==algorithm== is a well defined computational procedure that transforms input into outputs achieving desired input-output relationship.
- A ==correct algorithm== halts with the correct output for every input instance. We can then say that the algorithm solves the problem

Example of Problems and Instances

Computational Problem: Sorting

- **Input:** Sequence of n numbers $\langle a_1, \cdots, a_n \rangle$.

- **Output:** Permutation (reordering)

$$\langle a'_1, a'_2, \cdots, a'_n \rangle$$

such that $a'_1 \leq a'_2 \leq \cdots \leq a'_n$.

Instance of Problem: $\langle 8, 3, 6, 7, 1, 2, 9 \rangle$