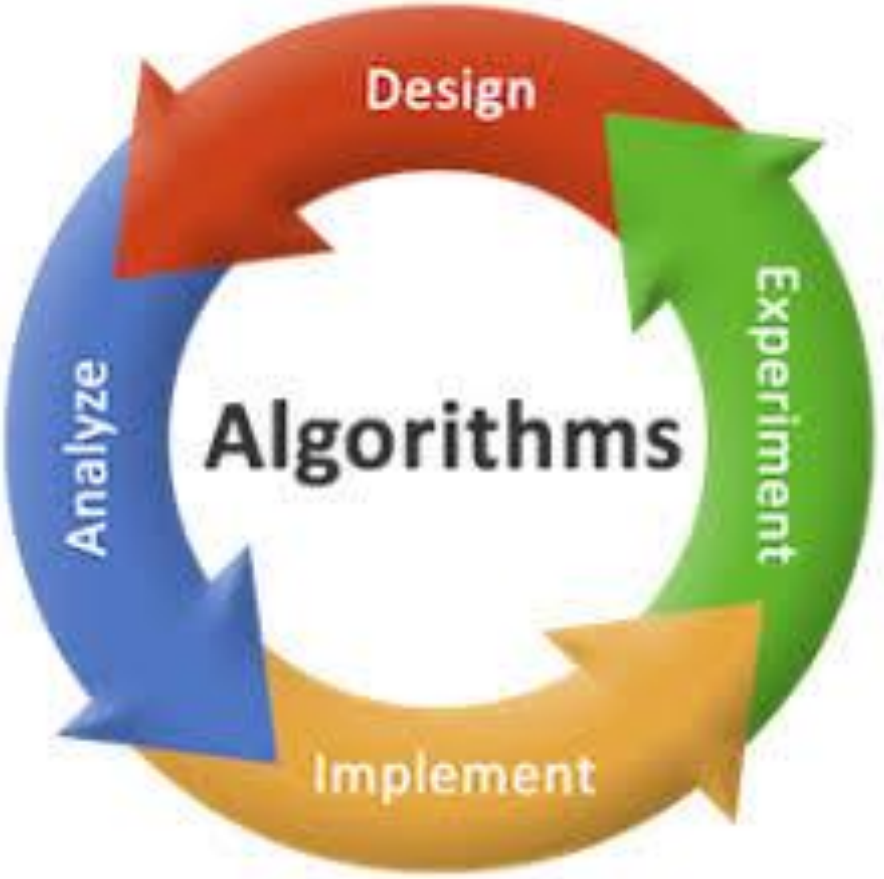


Design & Analysis of Algorithms

Lecture 2

Introduction to Algorithms

The Role of Algorithms in Computing

- What are algorithms?
- Why is the study of algorithms worthwhile?
- What is the role of algorithms relative to other technologies used in computers?

Algorithms

- Informally, an ***algorithm*** is any well-defined computational procedure that takes some value, or set of values, as ***input*** and produces some value, or set of values, as ***output***.

- An **algorithm** is thus a **sequence** of computational **steps** that transform the **input** into the **output**.

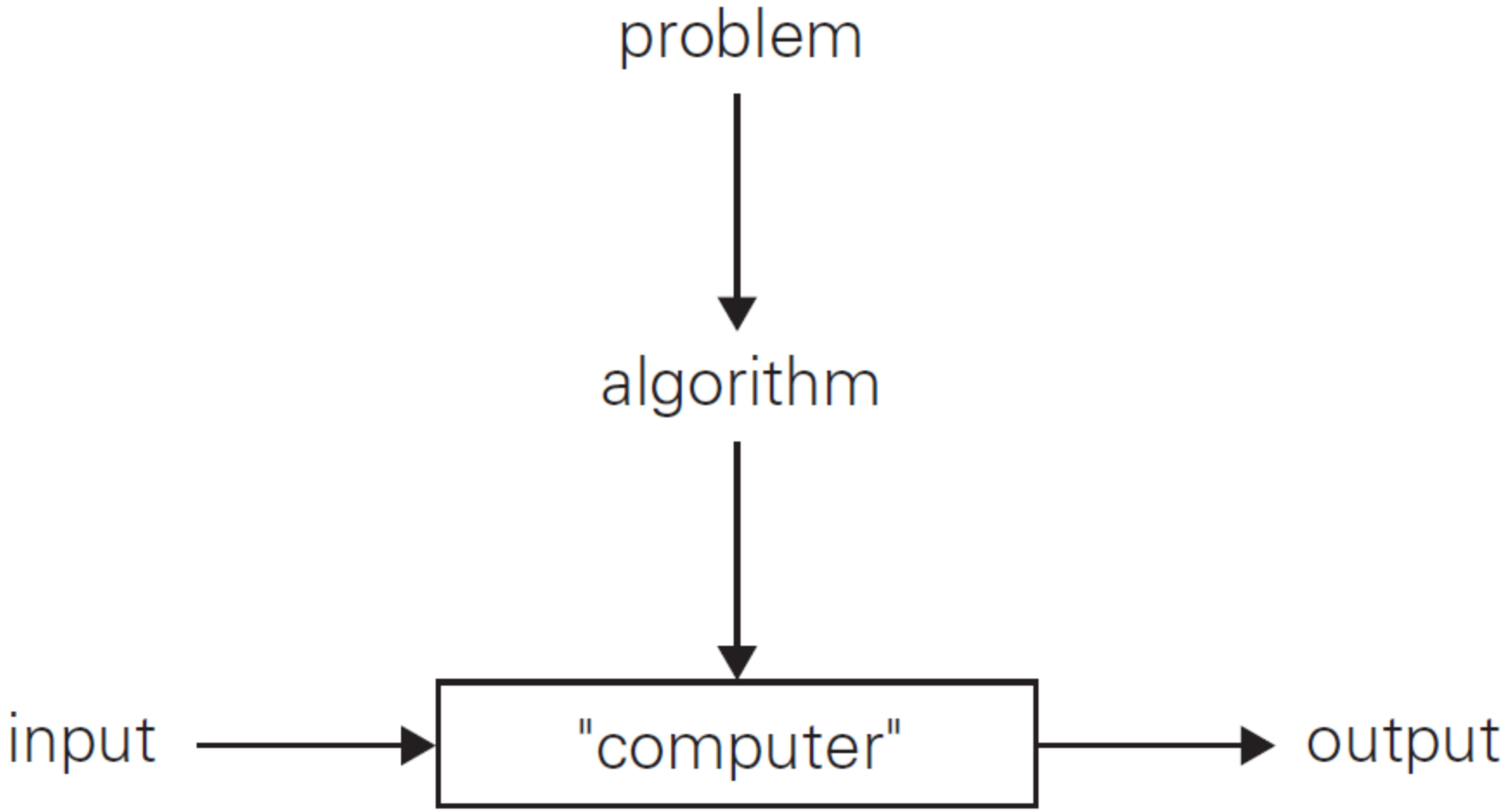
Algorithms

- We can also view an algorithm as a tool for solving a well-specified ***computational problem***.

- The statement of the **problem** specifies in general terms the desired **input/output relationship**.

- The **algorithm** describes a specific computational **procedure** for achieving that **input/output** relationship.

Algorithms



Algorithm: Instance

- In general, an ***instance of a problem*** consists of the input (satisfying whatever constraints are imposed in the problem statement) needed to compute a solution to the problem.

- **Example**: Linear Search

  Instance: list of **n** elements

Algorithm: Properties

- Correctness
- Finiteness
- Definiteness
- Effectiveness

Algorithm: Properties

- An **algorithm** is said to be **correct** if, for every input instance, it halts with the correct output.
  - We say that a correct algorithm solves the given computational problem.
  - An incorrect algorithm might not halt at all on some input instances, or it might halt with an answer other than the desired one.
  - Contrary to what one might expect, incorrect algorithms can sometimes be useful, if their error rate can be controlled.

Algorithm: Properties

- **Finiteness**: For any input, the algorithm must terminate after a finite number of steps.

Algorithm: Properties

- **Definiteness**: All steps of the algorithm must be precisely defined.

Algorithm: Properties

- **Effectiveness**: It must be possible to perform each step of the algorithm correctly and in a finite amount of time.

Algorithm: Some Points

- The range of inputs for which an algorithm works has to be specified carefully.
- The same algorithm can be represented in several different ways.
- There may exist several algorithms for solving the same problem.
- Algorithms for the same problem can be based on very different ideas and can solve the problem with dramatically different speeds.

Algorithm: Examples

- Search(A[n],K)
- GCD(A,B)
- Sort(A[n])
- GeneratePrimes(n) // less than n

References

- **Chapter 1**: Anany Levitin, "Introduction to the Design and Analysis of Algorithms", Pearson Education, Third Edition, 2017

- **Chapter 1**: Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms", MIT Press/PHI Learning Private Limited, Third Edition, 2012.

Homework

- Do some research on **al-Khorezmi** (also **al-Khwarizmi**), the man from whose name the word "**algorithm**" is derived.

- In particular, you should learn what the origins of the words "**algorithm**" and "**algebra**" have in common.