Introduction to Theory of Computation

Chapter 1

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Purpose of the Theory of Computation

Develop formal mathematical models of computation that reflect real-world computers.

- What are the mathematical properties of computer hardware and software?
- What is a computation and what is an algorithm? Can we give rigorous mathematical definitions of these notions?
- What are the limitations of computers? Can everything be computed?

Three areas of computer theory

- Complexity Theory
- Computability Theory
- Automata Theory

Complexity Theory

- Classify problems according to their degree of "difficulty." Give a rigorous proof that problems that seem to be "hard" are really "hard."

Computability Theory

- In 1930's Gödel, Turing and Church discovered that some fundamental mathematical problems cannot be solved by a computer.
- Classify problems as being solvable or unsolvable.

Automata Theory

- Three models:

  Finite Automata. These are used in text processing, compilers, and hardware design.

  Pushdown Automata. These are used to define programming languages and in Artificial Intelligence.

  Turing Machines. These form a simple abstract model of a real computer, such as your PC at home.

- Do these models have the same power, or can one model solve more problems than the other?

This course

- Start with Automata Theory, followed by Computability Theory.
- Complexity is covered in algorithms courses.

Practical applications

1. It is about mathematical properties of computer hardware and software.
2. This theory is very much relevant to practice, for example, in the design of new programming languages, compilers, string searching, pattern matching, computer security, artificial intelligence, *etc.*
3. This course helps you to learn problem solving skills. Theory teaches you how to think, prove, argue, solve problems, express, and abstract.
4. This theory simplifies the complex computers to an abstract and simple mathematical model, and helps you to understand them better.
5. This course is about rigorously analyzing capabilities and limitations of systems.