Theoretical Computer Science (Bridging Course)

Motivation

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Course Content

- Theoretical computer science
  - Automata theory
  - Formal languages, grammars
  - Turing machines, decidability
  - Computational complexity

- Introduction to logic
  - Propositional logic
  - First order logic

Purpose of the Course

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- What does it mean “to compute”?
- What can be computed?
- What can be computed efficiently?

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  - Automata theory
- What can be computed?
  - Computability/Decidability theory
- What can be computed efficiently?
  - Computational complexity

The Meaning of "Compute"

- Various mathematical models
  - Turing machines 1930s
  - Finite state automata 1940s
  - Formal grammars 1950s

- Practical aspects
  - Computer architectures 1970s
  - Programming languages 1970s
  - Compilers 1970s

Is my Function Computable?

- Write an algorithm to compute it
  - Can it compute every instance?
  - Will it always give you an answer?
  - Then you are done.
- If not, there are two choices
  - There is an algorithm but you don’t know
  - There exists no algorithm -> Unsolvable

- Formally prove computability is hard

Is my Function Computable?

- Many "known" problems are solvable
  - Sorting
  - Knapsack
- Other problems are not solvable
  - Halting problem
  - Gödel incompleteness theorem
- Don't try to solve unsolvable problems

Can I Compute it Efficiently?

- Some problems are “easy”
- Can we formally define it?

- Complexity theory comes to help
  - Complexity classes
  - Tools for checking class membership

- Important to know how hard it is

Can I Compute it Efficiently?

- Feasible problems
  - Sorting, linear programming, LZW
  - Time is polynomial in input
- Considered-unfeasible problems
  - Scheduling, Knapsack, TSP
  - Big open question: P=NP?
- Unfeasible problems
  - Quantified boolean formula
  - Time is exponential in input