Theoretical Computer Science and Mathematical Logic

Course Description

Theoretical computer science and mathematical logic form the theoretical basics of computer science. However, this is not “pure theory,” as these fundamentals are applied in many areas of computer science. These include, for example, the formulation of conditions in SQL queries or other programs based on statement and predicate logic, the use of finite state machines to specify systems with state transition diagrams, and the modeling of business and other processes with Petri nets. In addition, theoretical computer science and mathematical logic analyze the limits of computer science and computability, which cannot be exceeded irrespective of the technologies and algorithms used.

Contents

1. Propositional Logic
   1. Basic Concepts
   2. Calculation Rules and Normal Forms
   3. Interpretation and Satisfiability
   4. Proof by Contradiction and Resolution
   5. Soundness and Completeness
2. Predicate Logic
   1. Basic Concepts
   2. Resolution in Predicate Logic
   3. Completeness and Incompleteness
   4. Logic Programming with Prolog
3. Finite Automata and Regular Expressions
   1. Basic Concepts of Finite Automata
   2. Regular Expressions and Languages
   3. Practical Applications
4. Formal Languages and Grammars
   1. Basic Concepts
   2. The Chomsky Hierarchy
   3. Context-Free Languages (Type-2 Grammars)
   4. Context-Sensitive Languages (Type-1 Grammars)
5. Computability and Turing Machines
   1. Models of Computability
   2. Turing Machines
   3. More Models of Computability
   4. Computability and Decidability and the Halting Problem
6. Complexity Theory
   1. Landau’s Big O Notation
   2. Basic Concepts of Complexity Theory
   3. P = NP?
   4. NP-Complete Problems
7. Petri Nets
   1. Basic Concepts of Graphs and Petri Nets
   2. Modeling Properties of Concurrent Systems
   3. Reachability in Petri Nets
   4. Invariants in Petri Nets
8. Applications of Mathematical Logic and Theoretical Computer Science
   1. Parser and Compiler
   2. Program Verification
   3. Artificial Intelligence
   4. Cryptology