



Vorlesungsinhalt

Semester: Sommersemester 2013
Vorlesung: Komplexitätstheorie (IN2007) (4+2, 8 ECTS)
(mit Übungen)
Dozent: Prof. Dr. Ernst W. Mayr
Übungsleitung: Chris Pinkau

- Texte:** Sanjeev Arora, Boaz Barak:
“Computational Complexity — A Modern Approach”
Cambridge University Press: Cambridge-New York-Melbourne, 2009
- Giorgio Ausiello, Pierluigi Creszenzi, Giorgio Gambosi, Viggo Kann,
Alberto Marchetti-Spaccamela, Marco Protasi:
“Complexity and approximation — Combinatorial optimization problems
and their approximability properties”
Springer-Verlag: Berlin-Heidelberg, 1999
- José L. Balcázar, Josep Díaz, Joaquim Gabarró:
“Structural Complexity I (and II)//
EATCS Monographs on Theoretical Computer Science
Springer-Verlag: Berlin-Heidelberg, 1995
- Christos H. Papadimitriou:
“Computational Complexity”
Addison-Wesley Publishing Company: London-Amsterdam-New York, 1994
- Christos H. Papadimitriou, Kenneth Steiglitz:
“Combinatorial optimization: Algorithms and complexity”
Prentice-Hall, Englewood Cliffs, NJ, 1982
- Karl Rüdiger Reischuk:
“Komplexitätstheorie — Band I: Grundlagen”
B.G. Teubner: Stuttgart-Leipzig, 1999
- Michael Sipser:
“Introduction to the Theory of Computation”
International Edition, Thomson Course Technology: Australia-Canada-Mexico-Singapore-
Spain-United Kingdom-United States, 2006
- Ingo Wegener:
“The cocomplexity of Boolean functions”
Wiley-Teubner Series in Computer Science: Stuttgart-Chichester-New York, 1987
http://eccc.hpi-web.de/static/books/The_Complexity_of_Boolean_Functions/

Vorlesungsinhalt:

0. Organizational Matters

1. Planned Topics for the Course
2. Literature
3. Notational Conventions

I. The Computational Model

1. Some Basic Concepts
2. Turing Machines
 - 2.1 The Model
 - 2.2 Robustness
 - 2.3 Gödel Numbers and Universal Turing Machines
 - 2.4 Universal Simulation
 - 2.5 Non-computable Functions, the Halting Problem
 - 2.6 Deterministic Time and the Class \mathcal{P}

II. \mathcal{NP} and \mathcal{NP} -completeness

1. The Class \mathcal{NP}
 - 1.1 Relation between \mathcal{NP} and \mathcal{P}
 - 1.2 Non-deterministic Turing Machines
2. Reducibility and \mathcal{NP} -completeness
3. Cook-Levin Theorem
 - 3.1 Boolean Formulae and CNF
 - 3.2 The Cook-Levin Theorem
4. The Web of Reductions
5. Decision versus Search
6. $\text{co-}\mathcal{NP}$, EXP , and NEXP
7. Some Implications
 - 7.1 Mahaney's Theorem

III. Diagonalization

1. Time and Space Hierarchy
2. Non-deterministic Time Hierarchy
3. Ladner's Theorem
4. Oracle Machines and Limits of Diagonalization

IV. Space Complexity

1. Configuration Graphs
2. Some Space Complexity Classes
3. PSPACE Completeness
 - 3.1 Savitch's Theorem

- 3.2 PSPACE and Strategies for Game Playing
 - 4. \mathcal{NL} -Completeness
 - 4.1 Certificate Definition of \mathcal{NL} : Read-Once Certificates
 - 4.2 $\mathcal{NL} = \text{co-}\mathcal{NL}$
- V. The Polynomial Hierarchy and Alternation
 - 1. The Class Σ_2^P
 - 2. The Polynomial Hierarchy
 - 3. Alternating Turing Machines
 - 4. Time versus Alternations: Time-space Tradeoffs for SAT
 - 5. Defining the Hierarchy via Oracle Machines
- VI. Boolean Circuits
 - 1. Boolean Circuits and $\mathcal{P}_{\text{poly}}$
 - 2. Uniformly Generated Circuits
 - 3. Turing Machines that Take Advice
 - 4. $\mathcal{P}_{\text{poly}}$ and \mathcal{NP} : Karp-Lipton Theorem
 - 5. Circuit Lower (and Upper) Bounds
 - 6. Non-uniform Hierarchy Theorem
 - 7. Finer Gradations among Circuit Classes
 - 8. Circuits of Exponential Size
- VII. Randomized Computation
 - 1. Probabilistic Turing Machines
 - 2. Some Examples of PTMs
 - 3. One-sided and Zero-sided Error: \mathcal{RP} , $\text{co-}\mathcal{RP}$, ZPP
 - 4. The Robustness of Our Definitions
 - 5. $\text{BPP} \subseteq \mathcal{P}_{\text{poly}}$
 - 6. BPP Is in \mathcal{PH}
 - 7. Randomized Reductions
 - 8. Randomized Space-bounded Computation
- VIII. Interactive Proofs
 - 1. Interactive Proofs: Some Variations
 - 1.1 Interactive Proofs with Deterministic Verifier and Prover
 - 2. The Class \mathcal{IP} : Probabilistic Verifier
 - 3. Interactive Proof for Graph Nonisomorphism
 - 4. Public Coins and AM
 - 4.1 Simulating Private Coins
 - 4.2 Set Lower Bound Protocol
 - 4.3 Some Properties of \mathcal{IP} and AM
 - 4.4 Can GI Be \mathcal{NP} -complete?

5. $IP = PSPACE$
 - 5.1 Arithmetization
 - 5.2 Interactive Protocol for $\#SAT_D$
 - 5.3 Protocol for TQBF
6. The Power of the Prover
7. Multiprover Interactive Proofs
8. Program Checking
9. Outlook, More Topics in Complexity Theory