

# What Is Computational Complexity Theory?

# Computational Complexity Theory

**Osamu Watanabe**



## **Computational Complexity Theory:**

*Theory of Computational Complexity* Ding-Zhu Du, Ker-I Ko, 2014-07-18 Praise for the First Edition complete up to date coverage of computational complexity theory the book promises to become the standard reference on computational complexity Zentralblatt MATH A thorough revision based on advances in the field of computational complexity and readers feedback the Second Edition of *Theory of Computational Complexity* presents updates to the principles and applications essential to understanding modern computational complexity theory The new edition continues to serve as a comprehensive resource on the use of software and computational approaches for solving algorithmic problems and the related difficulties that can be encountered Maintaining extensive and detailed coverage *Theory of Computational Complexity Second Edition* examines the theory and methods behind complexity theory such as computational models decision tree complexity circuit complexity and probabilistic complexity The Second Edition also features recent developments on areas such as NP completeness theory as well as A new combinatorial proof of the PCP theorem based on the notion of expander graphs a research area in the field of computer science Additional exercises at varying levels of difficulty to further test comprehension of the presented material End of chapter literature reviews that summarize each topic and offer additional sources for further study *Theory of Computational Complexity Second Edition* is an excellent textbook for courses on computational theory and complexity at the graduate level The book is also a useful reference for practitioners in the fields of computer science engineering and mathematics who utilize state of the art software and computational methods to conduct research

*Computational Complexity Theory* Juris Hartmanis, 1989 Computational complexity theory is the study of the quantitative laws that govern computing This book contains the proceedings of the AMS Short Course on Computational Complexity Theory held at the Joint Mathematics Meetings in Atlanta in January 1988

*Computational Complexity Theory* Steven Rudich, Avi Wigderson, ***Theory of Computation*** Dexter C. Kozen, 2006-09-19 This textbook is uniquely written with dual purpose It cover cores material in the foundations of computing for graduate students in computer science and also provides an introduction to some more advanced topics for those intending further study in the area This innovative text focuses primarily on computational complexity theory the classification of computational problems in terms of their inherent complexity The book contains an invaluable collection of lectures for first year graduates on the theory of computation Topics and features include more than 40 lectures for first year graduate students and a dozen homework sets and exercises

*Complexity Theory of Real Functions* K. Ko, 2012-12-06 Starting with Cook s pioneering work on NP completeness in 1970 polynomial complexity theory the study of polynomial time com putability has quickly emerged as the new foundation of algorithms On the one hand it bridges the gap between the abstract approach of recursive function theory and the concrete approach of analysis of algorithms It extends the notions and tools of the theory of computability to provide a solid theoretical foundation for the study of computational complexity of practical problems In addition the theoretical studies of

the notion of polynomial time tractability some times also yield interesting new practical algorithms A typical exam ple is the application of the ellipsoid algorithm to combinatorial op timization problems see for example Lovasz 1986 On the other hand it has a strong influence on many different branches of mathe matics including combinatorial optimization graph theory number theory and cryptography As a consequence many researchers have begun to re examine various branches of classical mathematics from the complexity point of view For a given nonconstructive existence theorem in classical mathematics one would like to find a construc tive proof which admits a polynomial time algorithm for the solution One of the examples is the recent work on algorithmic theory of per mutation groups In the area of numerical computation there are also two tradi tionally independent approaches recursive analysis and numerical analysis

**Computational Complexity** Christos H. Papadimitriou,1994 The first unified introduction and reference for the field of computational complexity Virtually non existent only 25 years ago computational complexity has expanded tremendously and now comprises a major part of the research activity in theoretical science *Introduction to the Theory of Complexity* Daniel Pierre Bovet,Pierluigi Crescenzi,1994 Using a balanced approach that is partly algorithmic and partly structuralist this book systematically reviews the most significant results obtained in the study of computational complexity theory Features over 120 worked examples over 200 problems and 400 figures

**Advances in Computational Complexity Theory** Jin-yi Cai,1993-01-01 Recent papers on computational complexity theory Contributions by some of the leading experts in the field This book will prove to be of lasting value in this fast moving field as it provides expositions not found elsewhere The book touches on some of the major topics in complexity theory and thus sheds light on this burgeoning area of research

[Concise Guide to Computation Theory](#) Akira Maruoka,2011-04-29 This textbook presents a thorough foundation to the theory of computation Combining intuitive descriptions and illustrations with rigorous arguments and detailed proofs for key topics the logically structured discussion guides the reader through the core concepts of automata and languages computability and complexity of computation Topics and features presents a detailed introduction to the theory of computation complete with concise explanations of the mathematical prerequisites provides end of chapter problems with solutions in addition to chapter opening summaries and numerous examples and definitions throughout the text draws upon the author s extensive teaching experience and broad research interests discusses finite automata context free languages and pushdown automata examines the concept universality and limitations of the Turing machine investigates computational complexity based on Turing machines and Boolean circuits as well as the notion of NP completeness

*Computational Complexity: A Quantitative Perspective* Marius Zimand,2004-07-07 There has been a common perception that computational complexity is a theory of bad news because its most typical results assert that various real world and innocent looking tasks are infeasible In fact bad news is a relative term and indeed in some situations e g in cryptography we want an adversary to not be able to perform a certain task However a bad news result does not automatically become useful in such a scenario For this to happen its

hardness features have to be quantitatively evaluated and shown to manifest extensively The book undertakes a quantitative analysis of some of the major results in complexity that regard either classes of problems or individual concrete problems The size of some important classes are studied using resource bounded topological and measure theoretical tools In the case of individual problems the book studies relevant quantitative attributes such as approximation properties or the number of hard inputs at each length One chapter is dedicated to abstract complexity theory an older field which however deserves attention because it lays out the foundations of complexity The other chapters on the other hand focus on recent and important developments in complexity The book presents in a fairly detailed manner concepts that have been at the centre of the main research lines in complexity in the last decade or so such as average complexity quantum computation hardness amplification resource bounded measure the relation between one way functions and pseudo random generators the relation between hard predicates and pseudo random generators extractors derandomization of bounded error probabilistic algorithms probabilistically checkable proofs non approximability of optimization problems and others The book should appeal to graduate computer science students and to researchers who have an interest in computer science theory and need a good understanding of computational complexity e g researchers in algorithms AI logic and other disciplines Emphasis is on relevant quantitative attributes of important results in complexity Coverage is self contained and accessible to a wide audience Large range of important topics including derandomization techniques non approximability of optimization problems average case complexity quantum computation one way functions and pseudo random generators resource bounded measure and topology

*Computational Complexity Theory*, 2004 Computational Complexity Theory is the study of how much of a given resource is required to perform the computations that interest us the most Four decades of fruitful research have produced a rich and subtle theory of the relationship between different resource measures and problems At the core of the theory are some of the most alluring open problems in mathematics This book presents three weeks of lectures from the IAS Park City Mathematics Institute Summer School on computational complexity The first week gives a general introduction to the field including descriptions of the basic mo

*Computational Complexity Theory* American Mathematical Society, 2014-05-10 Computational complexity theory is the study of the quantitative laws that govern computing This book contains the proceedings of the AMS Short Course on Computational Complexity Theory held at the Joint Mathematics Meetings in Atlanta in January 1988

Computability and Complexity Theory Steven Homer, Alan L. Selman, 2001 This volume introduces materials that are the core knowledge in the theory of computation The book is self contained with a preliminary chapter describing key mathematical concepts and notations and subsequent chapters moving from the qualitative aspects of classical computability theory to the quantitative aspects of complexity theory Dedicated chapters on undecidability NP completeness and relative computability round off the work which focuses on the limitations of computability and the distinctions between feasible and intractable Topics and features Concise focused materials cover the

most fundamental concepts and results in the field of modern complexity theory including the theory of NP completeness NP hardness the polynomial hierarchy and complete problems for other complexity classes Contains information that otherwise exists only in research literature and presents it in a unified simplified manner for example about complements of complexity classes search problems and intermediate problems in NP Provides key mathematical background information including sections on logic and number theory and algebra Supported by numerous exercises and supplementary problems for reinforcement and self study purposes With its accessibility and well devised organization this text reference is an excellent resource and guide for those looking to develop a solid grounding in the theory of computing Beginning graduates advanced undergraduates and professionals involved in theoretical computer science complexity theory and computability will find the book an essential and practical learning tool

*Theories of Computational Complexity* C. Calude, 2011-08-18 This volume presents four machine independent theories of computational complexity which have been chosen for their intrinsic importance and practical relevance The book includes a wealth of results classical recent and others which have not been published before In developing the mathematics underlying the size dynamic and structural complexity measures various connections with mathematical logic constructive topology probability and programming theories are established The facts are presented in detail Extensive examples are provided to help clarify notions and constructions The lists of exercises and problems include routine exercises interesting results as well as some open problems

Logic, Automata, and Computational Complexity Bruce M. Kapron, 2023-05-22 Professor Stephen A Cook is a pioneer of the theory of computational complexity His work on NP completeness and the P vs NP problem remains a central focus of this field Cook won the 1982 Turing Award for his advancement of our understanding of the complexity of computation in a significant and profound way This volume includes a selection of seminal papers embodying the work that led to this award exemplifying Cook s synthesis of ideas and techniques from logic and the theory of computation including NP completeness proof complexity bounded arithmetic and parallel and space bounded computation These papers are accompanied by contributed articles by leading researchers in these areas which convey to a general reader the importance of Cook s ideas and their enduring impact on the research community The book also contains biographical material Cook s Turing Award lecture and an interview Together these provide a portrait of Cook as a recognized leader and innovator in mathematics and computer science as well as a gentle mentor and colleague

**Kolmogorov Complexity and Computational Complexity** Osamu Watanabe, 2012-12-06 The mathematical theory of computation has given rise to two important approaches to the informal notion of complexity Kolmogorov complexity usually a complexity measure for a single object such as a string a sequence etc measures the amount of information necessary to describe the object Computational complexity usually a complexity measure for a set of objects measures the computational resources necessary to recognize or produce elements of the set The relation between these two complexity measures has been considered for more than two decades and may interesting and

deep observations have been obtained In March 1990 the Symposium on Theory and Application of Minimal Length Encoding was held at Stanford University as a part of the AAAI 1990 Spring Symposium Series Some sessions of the symposium were dedicated to Kolmogorov complexity and its relations to the computational complexity theory and excellent expository talks were given there Feeling that due to the importance of the material some way should be found to share these talks with researchers in the computer science community I asked the speakers of those sessions to write survey papers based on their talks in the symposium In response five speakers from the sessions contributed the papers which appear in this book

**Introduction to Circuit Complexity** Heribert Vollmer,1999-06-23 An advanced textbook giving a broad modern view of the computational complexity theory of boolean circuits with extensive references for theoretical computer scientists and mathematicians

**Computational Complexity** Sanjeev Arora,Boaz Barak,2009-04-20 This beginning graduate textbook describes both recent achievements and classical results of computational complexity theory Requiring essentially no background apart from mathematical maturity the book can be used as a reference for self study for anyone interested in complexity including physicists mathematicians and other scientists as well as a textbook for a variety of courses and seminars More than 300 exercises are included with a selected hint set The book starts with a broad introduction to the field and progresses to advanced results Contents include definition of Turing machines and basic time and space complexity classes probabilistic algorithms interactive proofs cryptography quantum computation lower bounds for concrete computational models decision trees communication complexity constant depth algebraic and monotone circuits proof complexity average case complexity and hardness amplification derandomization and pseudorandom constructions and the PCP theorem

**Complexity and Real Computation** Lenore Blum,1998 The classical theory of computation has been a successful framework for theoretical computer science The thesis of this book however is that it provides an inadequate foundation for modern scientific computation where most of the algorithms are real number algorithms

Studies in Complexity Theory Ronald V. Book,1986

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