PERSPECTIVES IN LOGIC

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LOGICAL FOUNDATIONS OF PROOF COMPLEXITY

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Logical Foundations Of Proof Complexity Phuong Nguyen

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Logical Foundations of Proof Complexity Stephen Cook,Phuong Nguyen,2014-03-06 This book treats bounded arithmetic and propositional proof complexity from the point of view of computational complexity The first seven chapters include the necessary logical background for the material and are suitable for a graduate course Associated with each of many complexity classes are both a two sorted predicate calculus theory with induction restricted to concepts in the class and a propositional proof system The result is a uniform treatment of many systems in the literature including Buss s theories for the polynomial hierarchy and many disparate systems for complexity classes such as AC0 AC0 m TC0 NC1 L NL NC and P

Logical Foundations of Proof Complexity Stephen Cook,Phuong Nguyen,2010-01-25 This book treats bounded arithmetic and propositional proof complexity from the point of view of computational complexity The first seven chapters include the necessary logical background for the material and are suitable for a graduate course Associated with each of many complexity classes are both a two sorted predicate calculus theory with induction restricted to concepts in the class and a propositional proof system The complexity classes range from AC0 for the weakest theory up to the polynomial hierarchy Each bounded theorem in a theory translates into a family of quantified propositional tautologies with polynomial size proofs in the corresponding proof system The theory proves the soundness of the associated proof system The result is a uniform treatment of many systems in the literature including Buss s theories for the polynomial hierarchy and many disparate systems for complexity classes such as AC0 AC0 m TC0 NC1 L NL NC and P **Perspectives in Logic** Stephen Cook,2010 A treatise on bounded arithmetic and propositional proof complexity by the leader in the field Handbook of Satisfiability Armin Biere,Hans van Maaren,Toby Walsh,2021-05-15 Propositional logic has been recognized throughout the centuries as one of the cornerstones of reasoning in philosophy and mathematics Over time its formalization into Boolean algebra was accompanied by the recognition that a wide range of combinatorial problems can be expressed as propositional satisfiability SAT problems Because of this dual role SAT developed into a mature multi faceted scientific discipline and from the earliest days of computing a search was underway to discover how to solve SAT problems in an automated fashion This book the Handbook of Satisfiability is the second updated and revised edition of the book first published in 2009 under the same name The handbook aims to capture the full breadth and depth of SAT and to bring together significant progress and advances in automated solving Topics covered span practical and theoretical research on SAT and its applications and include search algorithms heuristics analysis of algorithms hard instances randomized formulae problem encodings industrial applications solvers simplifiers tools case studies and empirical results SAT is interpreted in a broad sense so as well as propositional satisfiability there are chapters covering the domain of quantified Boolean formulae QBF constraints programming techniques CSP for word level problems and their propositional encoding and satisfiability modulo theories SMT An extensive bibliography completes each chapter This second edition of the handbook will be of interest to researchers graduate students final year undergraduates and practitioners using or contributing to SAT and will provide both an inspiration and a rich resource for their work Edmund Clarke 2007 ACM Turing Award Recipient SAT solving is a key technology for 21st century computer science Donald Knuth 1974 ACM Turing Award Recipient SAT is evidently a killer app because it is key to the solution of so many other problems Stephen Cook 1982 ACM Turing Award Recipient The SAT problem is at the core of arguably the most fundamental question in computer science What makes a problem hard

Complexity of Computations and Proofs Jan Krajíček,2003 Mathematical Reviews ,2008 **How Uncertainty-Related Ideas Can Provide Theoretical Explanation For Empirical Dependencies** Martine Ceberio,Vladik Kreinovich,2021-03-20 This book shows how to provide uncertainty related theoretical justification for empirical dependencies on the examples from numerous application areas Such justifications are needed since without them practitioners may be reluctant to use these dependencies purely empirical formulas often turn out to hold only in some cases Examples of new theoretical explanations range from fundamental physics quark confinement galaxy superclusters etc and geophysics earthquake analysis to transportation and electrical engineering to computer science image processing quantum computing and pedagogy equity effect of repetitions The book is useful to students and specialists in the corresponding areas Most of the examples use common general techniques so the book is also useful to practitioners and researchers in other application areas who look for ways to provide theoretical justifications for their areas empirical dependencies

Proceedings of the Fourth Israel Symposium on Theory of Computing and Systems ,1996 This volume contains a selection of 29 papers presented at the Fourth Israeli Symposium on the theory of Computing and Systems held in Jerusalem in June of 1996 Topics include the Borowsky Gafni simulation algorithm arrangements of curves and surfaces in computational geometry advances in optical Logical Foundations of Mathematics and Computational Complexity Pavel Pudlák,2013-04-22 The two main themes of this book logic and complexity are both essential for understanding the main problems about the foundations of mathematics Logical Foundations of Mathematics and Computational Complexity covers a broad spectrum of results in logic and set theory that are relevant to the foundations as well as the results in computational complexity and the interdisciplinary area of proof complexity The author presents his ideas on how these areas are connected what are the most fundamental problems and how they should be approached In particular he argues that complexity is as important for foundations as are the more traditional concepts of computability and provability Emphasis is on explaining the essence of concepts and the ideas of proofs rather than presenting precise formal statements and full proofs Each section starts with concepts and results easily explained and gradually proceeds to more difficult ones The notes after each section present some formal definitions theorems and proofs Logical Foundations of Mathematics and Computational Complexity is aimed at graduate students of all fields of mathematics who are interested in logic complexity and foundations It will also be of interest for both physicists and philosophers who are curious to learn the basics of logic and complexity theory **Proof**

Complexity Jan Krajíček,2019-03-28 Proof complexity is a rich subject drawing on methods from logic combinatorics algebra and computer science This self contained book presents the basic concepts classical results current state of the art and possible future directions in the field It stresses a view of proof complexity as a whole entity rather than a collection of various topics held together loosely by a few notions and it favors more generalizable statements Lower bounds for lengths of proofs often regarded as the key issue in proof complexity are of course covered in detail However upper bounds are not neglected this book also explores the relations between bounded arithmetic theories and proof systems and how they can be used to prove upper bounds on lengths of proofs and simulations among proof systems It goes on to discuss topics that transcend specific proof systems allowing for deeper understanding of the fundamental problems of the subject Proof Theory and Logical Complexity Jean-Yves Girard,1987 Proof Theory and Logical Complexity Jean-Yves Girard,1987

Forcing with Random Variables and Proof Complexity Jan Krajíček,2010-12-23 This book introduces a new approach to building models of bounded arithmetic with techniques drawn from recent results in computational complexity Propositional proof systems and bounded arithmetics are closely related In particular proving lower bounds on the lengths of proofs in propositional proof systems is equivalent to constructing certain extensions of models of bounded arithmetic This offers a clean and coherent framework for thinking about lower bounds for proof lengths and it has proved quite successful in the past This book outlines a brand new method for constructing models of bounded arithmetic thus for proving independence results and establishing lower bounds for proof lengths The models are built from random variables defined on a sample space which is a non standard finite set and sampled by functions of some restricted computational complexity It will appeal to anyone interested in logical approaches to fundamental problems in complexity theory Arithmetic, Proof Theory, and Computational Complexity Peter Clote,Jan Krajícek,1993-05-06 This book principally concerns the rapidly growing area of Logical Complexity Theory the study of bounded arithmetic propositional proof systems length of proof etc and relations to computational complexity theory Additional features of the book include 1 the transcription and translation of a recently discovered 1956 letter from K Godel to J von Neumann asking about a polynomial time algorithm for the proof in k symbols of predicate calculus formulas equivalent to the P NP question 2 an OPEN PROBLEM LIST consisting of 7 fundamental and 39 technical questions contributed by many researchers together with a bibliography of relevant references

Proof Complexity and Feasible Arithmetics Paul W. Beame,Samuel R. Buss, Questions of mathematical proof and logical inference have been a significant thread in modern mathematics and have played a formative role in the development of computer science and artificial intelligence Research in proof complexity and feasible theories of arithmetic aims at understanding not only whether or not logical inferences can be made but also what resources are required to carry them out Understanding the resources required for logical inferences has major implications for some of the most important problems in computational complexity particularly the problem of whether or not NP is equal to co NP In addition these have important implications for the efficiency of automated reasoning systems The last dozen years have seen several breakthroughs in the study of these resource requirement Papers in this volume represent the proceedings of the DIMACS workshop on Feasible Arithmetics and Proof Complexity held in April 1996 in Rutgers NJ as part of the DIMACS Institute s Special Year on Logic and Algorithms This book brings together some of the most recent work of leading researchers in proof complexity and feasible arithmetic reflecting many of these advances It covers a number of aspects of the field including lower bounds in proof complexity witnessing theorems and proof systems for feasible arithmetic algebraic and combinatorial proof systems interpolation theorems and the relationship between proof complexity and Boolean circuit complexity *Proof Complexity Generators* Jan Krajíček,2025-05-31 The P vs NP problem is one of the fundamental problems of mathematics It asks whether propositional tautologies can be recognized by a polynomial time algorithm The problem would be solved in the negative if one could show that there are propositional tautologies that are very hard to prove no matter how powerful the proof system you use This is the foundational problem the NP vs coNP problem of proof complexity an area linking mathematical logic and computational complexity theory Written by a leading expert in the field this book presents a theory for constructing such hard tautologies It introduces the theory step by step starting with the historic background and a motivational problem in bounded arithmetic before taking the reader on a tour of various vistas of the field Finally it formulates several research problems to highlight new avenues of research **Proof Theory and Computer Programming** Ruy José Guerra Barretto de Queiroz,1990 **Proof Theory and Computer Programming** Ruy José Guerra Barretto de Queiroz,1990 **An Introduction to Proof Theory** Paolo Mancosu,Sergio Galvan,Richard Zach,2021 Proof theory is a central area of mathematical logic of special interest to philosophy It has its roots in the foundational debate of the 1920s in particular in Hilbert s program in the philosophy of mathematics which called for a formalization of mathematics as well as for a proof using philosophically unproblematic finitary means that these systems are free from contradiction Structural proof theory investigates the structure and properties of proofs in different formal deductive systems including axiomatic derivations natural deduction and the sequent calculus Central results in structural proof theory are the normalization theorem for natural deduction proved here for both intuitionistic and classical logic and the cut elimination theorem for the sequent calculus In formal systems of number theory formulated in the sequent calculus the induction rule plays a central role It can be eliminated from proofs of sequents of a certain elementary form every proof of an atomic sequent can be transformed into a simple proof This is Hilbert s central idea for giving finitary consistency proofs The proof requires a measure of proof complexity called an ordinal notation The branch of proof theory dealing with mathematical systems such as arithmetic thus has come to be called ordinal proof theory The theory of ordinal notations is developed here in purely combinatorial terms and the consistency proof for arithmetic presented in detail **Logical Approaches to the Complexity of Search Problems [microform] : Proof Complexity, Quantified Propositional Calculus, and Bounded Arithmetic** Tsuyoshi

Morioka,2005 For every binary predicate R there is a search problem QR for finding given x any y such that R x y holds QR is said to be total if every instance x has a solution y that is x y R x y holds Total search problems are commonplace in computer science and studying their complexity is therefore an important endeavour In this dissertation we present links between the complexity of solving QR and the difficulty of proving the totality of QR in the three logical formalisms propositional calculus quantified propositional calculus QPC and theories of bounded arithmetic These links allow logical approaches to the complexity of search problems We show several links between the complexity of a type 2 total search problem QR where R is represented by a first order existential sentence phi and the lengths of proofs of the propositional translations of phi in bounded depth Frege systems and the Nullstellensatz proof system In particular we prove the first direct links between reducibilities among type 2 search problems and lengths of propositional proofs Based on this and the results on propositional proof complexity we obtain a number of relative separations among the so called NP search classes such as Polynomial Local Search PLS Some of the relative separations we obtain are new We introduce a second order theory VNC1 of bounded arithmetic and show that the SB1 definable functions of VNC1 are precisely the NC1 functions We describe simple translations of every VNC1 proof into a family of polynomial size G 0 proofs From this and similar translation theorems for other bounded arithmetic theories we obtain the hardness of the Sqj witnessing problem for H for various H and j 1 Let H be a QPC proof system and j 1 We define the Sqj witnessing problem for H to be given an H proof of a prenex Sqj formula A and a truth assignment to the free variables of A find a witness for the outermost existential quantifiers of A These witnessing problems provide a tangible link between the proof lengths in QPC and the complexity of search problems and we consider them for various parameters We also introduce and study the new QPC proof systems G 0 and G0 and prove that the Sq1 witnessing problem for each is complete for NC 1 search problems Our proof involves proving the TC 0 versions of Gentzen s midsequent theorem and Herbrand s theorem

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