

*ACM Doctoral Dissertation
Award 1986*

**Computational
Limitations for
Small-Depth Circuits**

Johan Torkel Håstad

The MIT Press

Computational Limitations For Small Depth Circuits

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Computational Limitations For Small Depth Circuits:

Computational Limitations of Small-depth Circuits Johan Håstad, 1987 Proving lower bounds on the amount of resources needed to compute specific functions is one of the most active branches of theoretical computer science Significant progress has been made recently in proving lower bounds in two restricted models of Boolean circuits One is the model of small depth circuits and in this book Johan Torkel Hastad has developed very powerful techniques for proving exponential lower bounds on the size of small depth circuits computing functions The techniques described in Computational Limitations for Small Depth Circuits can be used to demonstrate almost optimal lower bounds on the size of small depth circuits computing several different functions such as parity and majority The main tool used in the proof of the lower bounds is a lemma stating that any AND of small fanout OR gates can be converted into an OR of small fanout AND gates with high probability when random values are substituted for the variables Hastad also applies this tool to relativized complexity and discusses in great detail the computation of parity and majority in small depth circuits Contents Introduction Small Depth Circuits Outline of Lower Bound Proofs Main Lemma Lower Bounds for Small Depth Circuits Functions Requiring Depth k to Have Small Circuits Applications to Relativized Complexity How Well Can We Compute Parity in Small Depth Is Majority Harder than Parity Conclusions John Hastad is a postdoctoral fellow in the Department of Mathematics at MIT Computational Limitations of Small Depth Circuits is a winner of the 1986 ACM Doctoral Dissertation Award [Mathematical Foundations of Computer Science 2004](#) Jirí Fiala, Václav Koubek, Jan Kratochvíl, 2004-08-09 This volume contains the papers presented at the 29th Symposium on Mathematical Foundations of Computer Science MFCS 2004 held in Prague Czech Republic August 22-27 2004 The conference was organized by the Institute for Theoretical Computer Science ITI and the Department of Theoretical Computer Science and Mathematical Logic KTIML of the Faculty of Mathematics and Physics of Charles University in Prague It was supported in part by the European Association for Theoretical Computer Science EATCS and the European Research Consortium for Informatics and Mathematics ERCIM Traditionally the MFCS symposia encourage high quality research in all branches of theoretical computer science Ranging in scope from automata formal languages data structures algorithms and computational geometry to complexity theory models of computation and applications including computational biology cryptography security and artificial intelligence the conference offers a unique opportunity to researchers from diverse areas to meet and present their results to a general audience The scientific program of this year's MFCS took place in the lecture halls of the recently reconstructed building of the Faculty of Mathematics and Physics in the historical center of Prague with the famous Prague Castle and other celebrated historical monuments in sight The view from the windows was a challenging competition for the speakers in the fight for the attention of the audience But we did not fear the result Due to the unusually tough competition for this year's MFCS the admitted presentations certainly attracted considerable interest The conference program and the proceedings consisted of 60 contributed papers selected by the Program Committee from a total of 167

submissions *Theoretical Advances in Neural Computation and Learning* Vwani Roychowdhury, Kai-Yeung Siu, Alon Orlitsky, 2012-12-06 For any research field to have a lasting impact there must be a firm theoretical foundation Neural networks research is no exception Some of the foundational concepts established several decades ago led to the early promise of developing machines exhibiting intelligence The motivation for studying such machines comes from the fact that the brain is far more efficient in visual processing and speech recognition than existing computers Undoubtedly neurological systems employ very different computational principles The study of artificial neural networks aims at understanding these computational principles and applying them in the solutions of engineering problems Due to the recent advances in both device technology and computational science we are currently witnessing an explosive growth in the studies of neural networks and their applications It may take many years before we have a complete understanding about the mechanisms of neural systems Before this ultimate goal can be achieved answers are needed to important fundamental questions such as a what can neural networks do that traditional computing techniques cannot b how does the complexity of the network for an application relate to the complexity of that problem and c how much training data are required for the resulting network to learn properly Everyone working in the field has attempted to answer these questions but general solutions remain elusive However encouraging progress in studying specific neural models has been made by researchers from various disciplines Introduction to Circuit Complexity Heribert Vollmer, 2013-04-17 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 **Mathematical Foundations of Computer Science 2006** Rastislav Královic, Pawel Urzyczyn, 2006-08-29 This book constitutes the refereed proceedings of the 31st International Symposium on Mathematical Foundations of Computer Science MFCS 2006 The book presents 62 revised full papers together with the full papers or abstracts of 7 invited talks All current aspects in theoretical computer science and its mathematical foundations are addressed from algorithms and data structures to complexity automata semantics logic formal specifications models of computation concurrency theory computational geometry and more **Open Problems in Mathematics** John Forbes Nash, Jr., Michael Th. Rassias, 2016-07-05 The goal in putting together this unique compilation was to present the current status of the solutions to some of the most essential open problems in pure and applied mathematics Emphasis is also given to problems in interdisciplinary research for which mathematics plays a key role This volume comprises highly selected contributions by some of the most eminent mathematicians in the international mathematical community on longstanding problems in very active domains of mathematical research A joint preface by the two volume editors is followed by a personal farewell to John F Nash Jr written by Michael Th Rassias An introduction by Mikhail Gromov highlights some of Nash's legendary mathematical achievements The treatment in this book includes open problems in the following fields algebraic geometry number theory analysis discrete mathematics PDEs differential geometry topology K theory game theory fluid

mechanics dynamical systems and ergodic theory cryptography theoretical computer science and more Extensive discussions surrounding the progress made for each problem are designed to reach a wide community of readers from graduate students and established research mathematicians to physicists computer scientists economists and research scientists who are looking to develop essential and modern new methods and theories to solve a variety of open problems

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