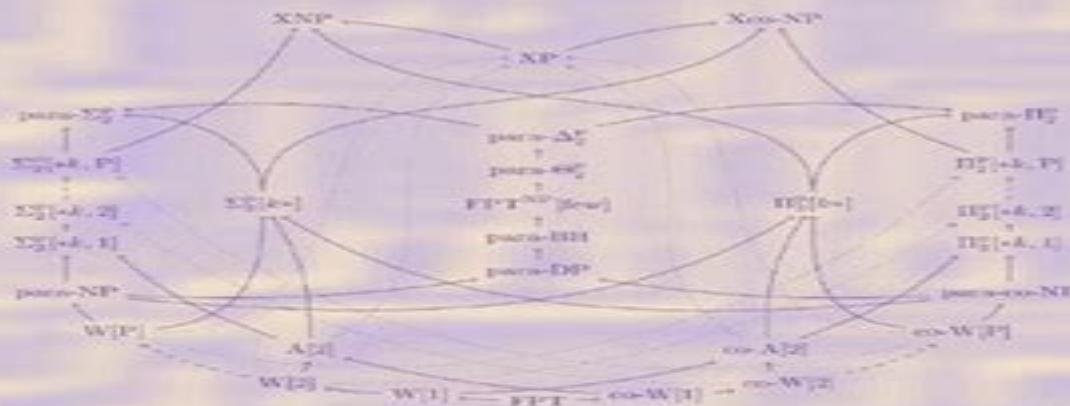


# Parameterized Complexity in the Polynomial Hierarchy

Extending Parameterized Complexity Theory to Higher Levels of the Hierarchy



# Parameterized Complexity Theory

**Rolf Niedermeier**

## **Parameterized Complexity Theory**

*Parameterized Complexity Theory* J. Flum, M. Grohe, 2006-05-01 Parameterized complexity theory is a recent branch of computational complexity theory that provides a framework for a refined analysis of hard algorithmic problems. The central notion of the theory fixed parameter tractability has led to the development of various new algorithmic techniques and a whole new theory of intractability. This book is a state of the art introduction to both algorithmic techniques for fixed parameter tractability and the structural theory of parameterized complexity classes and it presents detailed proofs of recent advanced results that have not appeared in book form before. Several chapters are each devoted to intractability algorithmic techniques for designing fixed parameter tractable algorithms and bounded fixed parameter tractability and subexponential time complexity. The treatment is comprehensive and the reader is supported with exercises, notes, a detailed index and some background on complexity theory and logic. The book will be of interest to computer scientists, mathematicians and graduate students engaged with algorithms and problem complexity.

Parameterized Complexity in the Polynomial Hierarchy Ronald de Haan, 2019-12-30 Parameterized Complexity in the Polynomial Hierarchy was co-recipient of the E.W. Beth Dissertation Prize 2017 for outstanding dissertations in the fields of logic, language and information. This work extends the theory of parameterized complexity to higher levels of the Polynomial Hierarchy PH. For problems at higher levels of the PH a promising solving approach is to develop fixed parameter tractable reductions to SAT and to subsequently use a SAT solving algorithm to solve the problem. In this dissertation a theoretical toolbox is developed that can be used to classify in which cases this is possible. The use of this toolbox is illustrated by applying it to analyze a wide range of problems from various areas of computer science and artificial intelligence.

*Parameterized Complexity* Rodney G. Downey, M.R. Fellows, 2012-12-06 The idea for this book was conceived over the second bottle of Villa Maria's Cabernet Medoc 89 at the dinner of the Australasian Combinatorics Conference held at Palmerston North, New Zealand in December 1990 where the authors first met and discovered they had a number of interests in common. Initially we embarked on a small project to try to formulate reductions to address the apparent parameterized intractability of DOMINATING SET and to introduce a structure in which to frame our answers. Having spent several months trying to get the definitions for the reductions right they now seem so obvious we turned to our tattered copies of Garey and Johnson's work [239]. We were stunned to find that virtually none of the classical reductions worked in the parameterized setting. We then wondered if we'd be able to find any interesting reductions. Several years, many more bottles, so many papers and reductions later it [3] seemed that we had unwittingly stumbled upon what we believe is a truly central and new area of complexity theory. It seemed to us that the material would be of great interest to people working in areas where exact algorithms for a small range of parameters are natural and useful e.g. Molecular Biology, VLSI design. The tractability theory was rich with distinctive and powerful techniques. The intractability theory seemed to have a deep structure and techniques all of its own.

**Invitation to**

**Fixed-Parameter Algorithms** Rolf Niedermeier, 2006-02-02 This research level text is an application oriented introduction to the growing and highly topical area of the development and analysis of efficient fixed parameter algorithms for optimally solving computationally hard combinatorial problems. The book is divided into three parts: a broad introduction that provides the general philosophy and motivation followed by coverage of algorithmic methods developed over the years in fixed parameter algorithmics forming the core of the book and a discussion of the essentials from parameterized hardness theory with a focus on W[1] hardness which parallels NP hardness then stating some relations to polynomial time approximation algorithms and finishing up with a list of selected case studies to show the wide range of applicability of the presented methodology. Aimed at graduate and research mathematicians, programmers, algorithm designers and computer scientists, the book introduces the basic techniques and results and provides a fresh view on this highly innovative field of algorithmic research.

**Parameterized and Exact Computation** Gregory Gutin, Stefan Szeider, 2013-11-29 This book constitutes the thoroughly refereed post conference proceedings of the 8th International Symposium on Parameterized and Exact Computation (IPEC 2013) in Sophia Antipolis, France, in September 2013. The 29 revised full papers presented were carefully reviewed and selected from 58 submissions. The topics addressed cover research in all aspects of parameterized exact algorithms and complexity including but are not limited to new techniques for the design and analysis of parameterized and exact algorithms, fixed parameter tractability results, parameterized complexity theory, relationship between parameterized complexity and traditional complexity classifications, applications of parameterized and exact computation and implementation issues of parameterized and exact algorithms.

[Parameterized Complexity Applied in Algorithmic Game Theory](#) Mahdi Pasha, 2011 Abstract: The modern mathematical treatment of the study of decisions taken by participants whose interests are in conflict is now generally labeled as 2game theory<sup>3</sup>. To understand these interactions the theory provides some solution concepts. An important such a concept is the notion of Nash equilibrium which provides a way of predicting the behavior of strategic participants in situations of conflicts. However many decision problems regarding to the computation of Nash equilibrium are computationally hard. Motivated by these hardness results we study the parameterized complexity of the Nash equilibrium. In parameterized complexity one considers computational problems in a twodimensional setting: the first dimension is the usual input size  $n$ , the second dimension is a positive integer  $k$ , the parameter. A problem is fixed parameter tractable (FPT) if it can be solved in time  $f(k)n^O(1)$  where  $f$  denotes a computable, possibly exponential function. We show that some decision problems regarding to the computation of Nash equilibrium are hard even in parameterized complexity theory. However we provide FPT algorithms for some other problems relevant to the computation of Nash equilibrium.

[Parameterized and Exact Computation](#) Martin Grohe, Rolf Niedermeier, 2008-04-25 This book constitutes the refereed proceedings of the Third International Workshop on Parameterized and Exact Computation (IWPEC 2008) held in Victoria, Canada, in May 2008, co-located with the 40th ACM Symposium on Theory of Computing (STOC 2008). The 17 revised

full papers presented together with 3 invited lectures were carefully reviewed and selected from 32 submissions The topics addressed cover research in all aspects of parameterized and exact computation and complexity including but not limited to new techniques for the design and analysis of parameterized and exact algorithms parameterized complexity theory relationship between parameterized complexity and traditional complexity classifications applications of parameterized computation implementation and experiments high performance computing and fixed parameter tractability *The Multivariate Algorithmic Revolution and Beyond* Hans L. Bodlaender, Rodney Downey, Fedor V. Fomin, Dániel Marx, 2012-06-16

Parameterized complexity is currently a thriving field in complexity theory and algorithm design A significant part of the success of the field can be attributed to Michael R Fellows This Festschrift has been published in honor of Mike Fellows on the occasion of his 60th birthday It contains 20 papers that showcase the important scientific contributions of this remarkable man describes the history of the field of parameterized complexity and also reflects on other parts of Mike Fellows s unique and broad range of interests including his work on the popularization of discrete mathematics for young children The volume contains several surveys that introduce the reader to the field of parameterized complexity and discuss important notions results and developments in this field

### **Parameterized and Exact Computation**

Marek Cygan, Pinar Heggernes, 2014-12-02 This book constitutes the thoroughly refereed post conference proceedings of the 9th International Symposium on Parameterized and Exact Computation IPEC 2014 in Wroclaw Poland in September 2014 The 27 revised full papers presented together with one invited paper were carefully reviewed and selected from 42 submissions The topics addressed cover research in all aspects of parameterized exact algorithms and complexity including but are not limited to new techniques for the design and analysis of parameterized and exact algorithms fixed parameter tractability results parameterized complexity theory relationship between parameterized complexity and traditional complexity classifications applications of parameterized and exact exponential time computation and implementation issues of parameterized and exact exponential time algorithms

### **Parameterized and Exact Computation**

Dániel Marx, Peter Rossmanith, 2012-03-16 This book constitutes the thoroughly refereed post conference proceedings of the 6th International Symposium on Parameterized and Exact Computation IPEC 2011 in Saarbrücken Germany in September 2011 The 21 revised full papers presented were carefully reviewed and selected from 40 submissions The topics addressed cover research in all aspects of parameterized and exact computation and complexity including but not limited to new techniques for the design and analysis of parameterized and exact algorithms fixed parameter tractability results parameterized complexity theory relationship between parameterized complexity and traditional complexity classifications applications of parameterized and exact computation and implementation issues of parameterized and exact algorithms

### *Parameterized and Exact Computation*

Dimitrios M. Thilikos, Gerhard J. Woeginger, 2012-08-30 This book constitutes the refereed proceedings of the 7th International Symposium on Parameterized and Exact Computation IPEC 2012 in Ljubljana Slovenia in September 2012 The 21 revised full

papers presented together with 2 keynote talks were carefully reviewed and selected from 37 submissions. The topics addressed cover research in all aspects of parameterized exact algorithms and complexity including but are not limited to new techniques for the design and analysis of parameterized and exact algorithms, fixed parameter tractability results, parameterized complexity theory, relationship between parameterized complexity and traditional complexity classifications, applications of parameterized and exact computation and implementation issues of parameterized and exact algorithms.

**ECAI 2016** G.A. Kaminka, M. Fox, P. Bouquet, 2016-08-24 Artificial Intelligence continues to be one of the most exciting and fast developing fields of computer science. This book presents the 177 long papers and 123 short papers accepted for ECAI 2016, the latest edition of the biennial European Conference on Artificial Intelligence Europe's premier venue for presenting scientific results in AI. The conference was held in The Hague, the Netherlands from August 29 to September 2, 2016. ECAI 2016 also incorporated the conference on Prestigious Applications of Intelligent Systems PAIS 2016 and the Starting AI Researcher Symposium STAIRS. The papers from PAIS are included in this volume, the papers from STAIRS are published in a separate volume in the Frontiers in Artificial Intelligence and Applications FAIA series. Organized by the European Association for Artificial Intelligence EurAI and the Benelux Association for Artificial Intelligence BNVKI, the ECAI conference provides an opportunity for researchers to present and hear about the very best research in contemporary AI. This proceedings will be of interest to all those seeking an overview of the very latest innovations and developments in this field.

**Computation and Logic in the Real World** S. Barry Cooper, 2007-06-11 This book constitutes the refereed proceedings of the Third International Conference on Computability in Europe CiE 2007 held in Sienna, Italy in June 2007. The 50 revised full papers presented together with 36 invited papers were carefully reviewed and selected from 167 submissions.

**Algorithms and Theory of Computation Handbook, Volume 1** Mikhail J. Atallah, Marina Blanton, 2009-11-20. Algorithms and Theory of Computation Handbook, Second Edition: General Concepts and Techniques provides an up to date compendium of fundamental computer science topics and techniques. It also illustrates how the topics and techniques come together to deliver efficient solutions to important practical problems. Along with updating and revising many STACS 2002 Helmut Alt, Afonso Ferreira, 2003-08-03. This book constitutes the refereed proceedings of the 19th Annual Symposium on Theoretical Aspects of Computer Science STACS 2002 held in Antibes Juan les Pins France in March 2002. The 50 revised full papers presented together with three invited papers were carefully reviewed and selected from a total of 209 submissions. The book offers topical sections on algorithms, current challenges, computational and structural complexity, automata and formal languages and logic in computer science. **Parameterized Complexity** Rodney G. Downey, M.R. Fellows, Michael Ralph Fellows, 1999. This monograph presents an approach to complexity theory which offers a means of analyzing algorithms in terms of their tractability. The authors consider the problem in terms of parameterized languages and taking  $k$  slices of the language. In doing so the reader is introduced to new classes of algorithms which may be analyzed more

precisely than heretofore. The authors have made the book as self contained as possible and a lot of background material is included. As a result computer scientists, mathematicians and graduate students interested in the design and analysis of algorithms will find much of interest in this book. Automata, Languages and Programming Josep Díaz, 2004-08-17. This book constitutes the refereed proceedings of the 31st International Colloquium on Automata Languages and Programming (ICALP 2004) held in Turku, Finland in July 2004. The 97 revised full papers presented together with abstracts of 6 invited talks were carefully reviewed and selected from 379 submissions. The papers address all current issues in theoretical computer science including algorithms, automata, complexity, cryptography, database, logics, program semantics and programming theory.

ECAI 2012 C. Bessiere, 2012-08-15. Artificial intelligence AI plays a vital part in the continued development of computer science and informatics. The AI applications employed in fields such as medicine, economics, linguistics, philosophy, psychology and logical analysis, not forgetting industry, are now indispensable for the effective functioning of a multitude of systems. This book presents the papers from the 20th biennial European Conference on Artificial Intelligence (ECAI 2012) held in Montpellier, France in August 2012. The ECAI conference remains Europe's principal opportunity for researchers and practitioners of Artificial Intelligence to gather and to discuss the latest trends and challenges in all subfields of AI as well as to demonstrate innovative applications and uses of advanced AI technology. ECAI 2012 featured four keynote speakers, an extensive workshop program, seven invited tutorials and the new 'Frontiers of Artificial Intelligence' track in which six invited speakers delivered perspective talks on particularly interesting new research results, directions and trends in Artificial Intelligence or in one of its related fields. The proceedings of PAIS 2012 and the System Demonstrations Track are also included in this volume which will be of interest to all those wishing to keep abreast of the latest developments in the field of AI. Proceedings of the 36th Annual ACM Symposium on the Theory of Computing, 2004. Computational Complexity, 2003. This is an annual conference that deals with computational complexity in very broad terms. Complexity 2003 looks into topics such as complexity classes, algebraic complexity, proof complexity, interactive proof systems, Kolmogorov complexity, Reducibility, communication complexity, complexity and logic, nonapproximability, cryptographic complexity, complexity and learning, quantum computation, circuits and other concrete computational models.

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