

Juraj Hromkovič

Algorithmics for Hard Problems

Introduction to Combinatorial Optimization,
Randomization, Approximation, and Heuristics

2nd Edition



Springer

Algorithmics For Hard Problems Introduction To Combinatorial Optimization Randomization Approximation And Heuristics

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Algorithmics For Hard Problems Introduction To Combinatorial Optimization Randomization Approximation And Heuristics:

Algorithmics for Hard Problems Juraj Hromkovič, 2013-03-14 Algorithmic design especially for hard problems is more essential for success in solving them than any standard improvement of current computer technologies. Because of this the design of algorithms for solving hard problems is the core of current algorithmic research from the theoretical point of view as well as from the practical point of view. There are many general text books on algorithmics and several specialized books devoted to particular approaches such as local search randomization approximation algorithms or heuristics. But there is no textbook that focuses on the design of algorithms for hard computing tasks and that systematically explains combines and compares the main possibilities for attacking hard algorithmic problems. As this topic is fundamental for computer science this book tries to close this gap. Another motivation and probably the main reason for writing this book is connected to education. The considered area has developed very dynamically in recent years and the research on this topic discovered several profound results new concepts and new methods. Some of the achieved contributions are so fundamental that one can speak about paradigms which should be included in the education of every computer science student. Unfortunately this is very far from reality. This is because these paradigms are not sufficiently known in the computer science community and so they are insufficiently communicated to students and practitioners.

Algorithmics for Hard Problems Juraj Hromkovič, 2001-05-22 An introduction to the methods of designing algorithms for hard computing tasks concentrating mainly on approximate randomized and heuristic algorithms and on the theoretical and experimental comparison of these approaches according to the requirements of the practice. This is the first book to systematically explain and compare all the main possibilities of attacking hard computing problems. It also closes the gap between theory and practice by providing at once a graduate textbook and a handbook for practitioners dealing with hard computing problems.

[Algorithmics for Hard Problems](#) Juraj Hromkovič, 2013-03-14 Algorithmic design especially for hard problems is more essential for success in solving them than any standard improvement of current computer technologies. Because of this the design of algorithms for solving hard problems is the core of current algorithmic research from the theoretical point of view as well as from the practical point of view. There are many general textbooks on algorithmics and several specialized books devoted to particular approaches such as local search randomization approximation algorithms or heuristics. But there is no textbook that focuses on the design of algorithms for hard computing tasks and that systematically explains combines and compares the main possibilities for attacking hard algorithmic problems. As this topic is fundamental for computer science this book tries to close this gap. Another motivation and probably the main reason for writing this book is connected to education. The considered area has developed very dynamically in recent years and the research on this topic discovered several profound results new concepts and new methods. Some of the achieved contributions are so fundamental that one can speak about paradigms

which should be included in the education of every computer science student Unfortunately this is very far from reality This is because these paradigms are not sufficiently known in the computer science community and so they are insufficiently communicated to students and practitioners

Handbook of Approximation Algorithms and Metaheuristics Teofilo F. Gonzalez, 2007-05-15 Delineating the tremendous growth in this area the Handbook of Approximation Algorithms and Metaheuristics covers fundamental theoretical topics as well as advanced practical applications It is the first book to comprehensively study both approximation algorithms and metaheuristics Starting with basic approaches the handbook presents the methodologies to design and analyze efficient approximation algorithms for a large class of problems and to establish inapproximability results for another class of problems It also discusses local search neural networks and metaheuristics as well as multiobjective problems sensitivity analysis and stability After laying this foundation the book applies the methodologies to classical problems in combinatorial optimization computational geometry and graph problems In addition it explores large scale and emerging applications in networks bioinformatics VLSI game theory and data analysis Undoubtedly sparking further developments in the field this handbook provides the essential techniques to apply approximation algorithms and metaheuristics to a wide range of problems in computer science operations research computer engineering and economics Armed with this information researchers can design and analyze efficient algorithms to generate near optimal solutions for a wide range of computational intractable problems

Finite Model Theory and Its Applications Erich Grädel, Phokion G. Kolaitis, Leonid Libkin, Maarten Marx, Joel Spencer, Moshe Y. Vardi, Yde Venema, Scott Weinstein, 2007-04-24 Finite model theory as understood here is an area of mathematical logic that has developed in close connection with applications to computer science in particular the theory of computational complexity and database theory One of the fundamental insights of mathematical logic is that our understanding of mathematical phenomena is enriched by elevating the languages we use to describe mathematical structures to objects of explicit study If mathematics is the science of patterns then the media through which we discern patterns as well as the structures in which we discern them command our attention It is this aspect of logic which is most prominent in model theory the branch of mathematical logic which deals with the relation between a formal language and its interpretations No wonder then that mathematical logic and finite model theory in particular should find manifold applications in computer science from specifying programs to querying databases computer science is rife with phenomena whose understanding requires close attention to the interaction between language and structure This volume gives a broad overview of some central themes of finite model theory expressive power descriptive complexity and zero one laws together with selected applications to database theory and artificial intelligence especially constraint databases and constraint satisfaction problems The final chapter provides a concise modern introduction to modal logic which emphasizes the continuity in spirit and technique with finite model theory

Complexity Theory and Cryptology Jörg Rothe, 2005-07-22 Modern cryptology increasingly employs mathematically rigorous concepts and methods from

complexity theory Conversely current research topics in complexity theory are often motivated by questions and problems from cryptology This book takes account of this situation and therefore its subject is what may be dubbed cryptocomplexity a kind of symbiosis of these two areas This book is written for undergraduate and graduate students of computer science mathematics and engineering and can be used for courses on complexity theory and cryptology preferably by stressing their interrelation Moreover it may serve as a valuable source for researchers teachers and practitioners working in these fields Starting from scratch it works its way to the frontiers of current research in these fields and provides a detailed overview of their history and their current research topics and challenges

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

Software Engineering 1 Dines Bjørner,2007-06-01

The art craft discipline logic practice and science of developing large scale software products needs a believable professional base The textbooks in this three volume set combine informal engineeringly sound practice with the rigour of formal mathematics based approaches Volume 1 covers the basic principles and techniques of formal methods abstraction and modelling First this book provides a sound but simple basis of insight into discrete mathematics numbers sets Cartesians types functions the Lambda Calculus algebras and mathematical logic Then it trains its readers in basic property and model oriented specification principles and techniques The model oriented concepts that are common to such specification languages as B VDM SL and Z are explained here using the RAISE specification language RSL This book then covers the basic principles of applicative functional imperative and concurrent parallel specification programming Finally the volume contains a comprehensive glossary of software engineering and extensive indexes and references These volumes are suitable for self study by practicing software engineers and for use in university undergraduate and graduate courses on software engineering Lecturers will be supported with a comprehensive guide to designing modules based on the textbooks with solutions to many of the exercises presented and with a complete set of lecture slides

Software Engineering 3 Dines Bjørner,2006-03-09

The final installment in this three volume set is based on this maxim Before software can be designed its requirements must be well understood and before the requirements

can be expressed properly the domain of the application must be well understood The book covers the process from the development of domain descriptions through the derivation of requirements prescriptions from domain models to the refinement of requirements into software architectures and component design **Duration Calculus** Chaochen Zhou, Michael R. Hansen, 2013-03-14 Duration calculus constitutes a formal approach to the development of real time systems as an interval logic with special features for expressing and analyzing time durations of states in real time systems it allows for representing and formally reasoning about requirements and designs at an appropriate level of abstraction This book presents the logical foundations of duration calculus in a coherent and thorough manner Through selective case studies it explains how duration calculus can be applied to the formal specification and verification of real time systems The book also contains an extensive survey of the current research in this field The material included in this book has been used for graduate and postgraduate courses while it is also suitable for experienced researchers and professionals

Fundamentals of Algebraic Graph Transformation Hartmut Ehrig, Karsten Ehrig, Ulrike Prange, Gabriele Taentzer, 2006-05-01 Graphs are widely used to represent structural information in the form of objects and connections between them Graph transformation is the rule based manipulation of graphs an increasingly important concept in computer science and related fields This is the first textbook treatment of the algebraic approach to graph transformation based on algebraic structures and category theory Part I is an introduction to the classical case of graph and typed graph transformation In Part II basic and advanced results are first shown for an abstract form of replacement systems so called adhesive high level replacement systems based on category theory and are then instantiated to several forms of graph and Petri net transformation systems Part III develops typed attributed graph transformation a technique of key relevance in the modeling of visual languages and in model transformation Part IV contains a practical case study on model transformation and a presentation of the AGG attributed graph grammar tool environment Finally the appendix covers the basics of category theory signatures and algebras The book addresses both research scientists and graduate students in computer science mathematics and engineering *Semantic Integration of Heterogeneous Software Specifications* Martin Große-Rhode, 2013-03-09 In a model based development of software systems different views on a system are elaborated using appropriate modeling languages and techniques Because of the unavoidable heterogeneity of the viewpoint models a semantic integration is required to establish the correspondences of the models and allow checking of their relative consistency The integration approach introduced in this book is based on a common semantic domain of abstract systems their composition and development Its applicability is shown through semantic interpretations and compositional comparisons of different specification approaches These range from formal specification techniques like process calculi Petri nets and rule based formalisms to semiformal software modeling languages like those in the UML family **A Practical Theory of Reactive Systems** R. Kurki-Suonio, 2005-07-20 A man may imagine he understands something but still not

understand anything in the way that he ought to Paul of Tarsus 1 Corinthians 8 2 Calling this a practical theory may require some explanation Theory and practice are often thought of as two different worlds governed by different ideals principles and laws David Lorge Parnas for instance who has contributed much to our theoretical understanding of software engineering and also to sound use of theory in the practice of it likes to point out that theoretically is synonymous to not really In applied mathematics the goal is to discover useful connections between these two worlds My thesis is that in software engineering this two world view is inadequate and a more intimate interplay is required between theory and practice That is both theoretical and practical components should be integrated into a practical theory It should be clear from the above that the intended readership of this book is not theoreticians They would probably have difficulties in appreciating a book on theory where the presentation does not proceed in a logical sequence from basic definitions to theorems and mathematical proofs followed by application examples In fact all this would not constitute what I understand by a practical theory in this context

Restricted-Orientation Convexity Eugene Fink, Derick Wood, 2012-12-06 Restricted orientation convexity is the study of geometric objects whose intersections with lines from some fixed set are connected This notion generalizes standard convexity and several types of nontraditional convexity We explore the properties of this generalized convexity in multidimensional Euclidean space describes restricted orientation analogs of lines hyperplanes flats and halfspaces and identify major properties of standard convex sets that also hold for restricted orientation convexity We then introduce the notion of strong restricted orientation convexity which is an alternative generalization of convexity and show that its properties are also similar to those of standard convexity

DNA Computing Gheorghe Paun, Grzegorz Rozenberg, Arto Salomaa, 2013-03-09 This is the first book on DNA computing a molecular approach that may revolutionize computing replacing silicon with carbon and microchips with DNA molecules The book starts with an introduction to DNA computing exploring the power of complementarity the basics of biochemistry and language and computation theory It then brings the reader to the most advanced theories developed thus far in this emerging research area

Verification of Reactive Systems Klaus Schneider, 2003-10-16 This book is a solid foundation of the most important formalisms used for specification and verification of reactive systems In particular the text presents all important results on modal calculus with automata and temporal logics shows the relationships between these formalisms and describes state of the art verification procedures for them It also discusses advantages and disadvantages of these formalisms and shows up their strengths and weaknesses Most results are given with detailed proofs so that the presentation is almost self contained Includes all definitions without relying on other material Proves all theorems in detail Presents detailed algorithms in pseudo code for verification as well as translations to other formalisms

Dissemination of Information in Optical Networks: Subir Bandyopadhyay, 2007-10-24 Optical networks and the related technologies network management software and services have undergone remarkable developments and such networks are now the ultra high speed backbone networks for communication

Wavelength Division Multiplexing WDM the ability to support multiple communication pathways over the same fiber enables efficient use of the enormous capability for data communication of optical networks This book gives a broad overview of techniques used in the design of WDM networks for efficient dissemination of information in computer networks It starts with an overview of the hardware components then provides a thorough review of WDM wavelength routed networks algorithms for route and wavelength assignment design of broadcast and select networks logical topology design and techniques to handle faults and algorithms for efficient use of optical networks Each topic has been covered rigorously with emphasis on detailed explanations of the approaches used starting from the fundamentals up to the state of the art The optimization techniques covered in the book include graph theoretic algorithms mixed integer linear programming and heuristics The book is intended for beginners as well as for specialists and the reader should be able to design WDM networks and follow developments in the field Each chapter contains a detailed annotated bibliography There are numerous exercises for the reader to test understanding of the subject while readers unfamiliar with mathematical programming techniques and network flow optimization are offered short easy to understand appendices at the end of the book

Informed Machine Learning Daniel Schulz, Christian Bauckhage, 2025-05-11 This open access book presents the concept of Informed Machine Learning and demonstrates its practical use with a compelling collection of applications of this paradigm in industrial and business use cases These range from health care over manufacturing and material science to more advanced combinations with deep learning say in the form of physical informed neural networks The book is intended for those interested in modern informed machine learning for a wide range of practical applications where the aspect of small data sets is a challenge Machine Learning with small amounts of data After the recent success of Artificial Intelligence based on training with massive amounts of data this idea may sound exotic However it addresses crucial needs of practitioners in industry While many industrial applications stand to benefit from the use of AI the amounts of data needed by current learning paradigms are often hard to come by in industrial settings As an alternative learning methods and models are called for which integrate other sources of knowledge in order to compensate for the lack of data This is where the principle of Informed Machine Learning comes into play Informed Machine Learning combines purely data driven learning and knowledge based techniques to learn from both data and knowledge This has several advantages It reduces the need for data it often results in smaller less complex and more robust models and even makes machine learning applicable in settings where data is scarce The kind of knowledge to be incorporated into learning processes can take many different forms for example differential equations analytical models simulation results logical rules knowledge graphs or human feedback which makes the approach overall very powerful and widely applicable

Elements of Finite Model Theory Leonid Libkin, 2013-03-09 Finite model theory is an area of mathematical logic that grew out of computer science applications The main sources of motivational examples for finite model theory are found in database theory computational complexity and formal languages although in recent years

connections with other areas such as formal methods and verification and artificial intelligence have been discovered. The birth of finite model theory is often identified with Trakhtenbrot's result from 1950 stating that validity over finite models is not recursively enumerable in other words completeness fails over finite models. The technique of the proof based on encoding Turing machine computations as finite structures was reused by Fagin almost a quarter century later to prove his celebrated result that put the equality sign between the class NP and existential second order logic thereby providing a machine independent characterization of an important complexity class. In 1982 Immerman and Vardi showed that over ordered structures a fixed point extension of first order logic captures the complexity class PTIME of polynomial time computable properties. Shortly thereafter logical characterizations of other important complexity classes were obtained. This line of work is often referred to as descriptive complexity. A different line of finite model theory research is associated with the development of relational databases. By the late 1970s the relational database model had replaced others and all the basic query languages for it were essentially first order predicate calculus or its minor extensions.

The Parametric Lambda Calculus Simona Ronchi Della Rocca, Luca Paolini, 2013-03-09 The book contains a completely new presentation of classical results in the field of Lambda Calculus together with new results. The text is unique in that it presents a new calculus Parametric Lambda Calculus which can be instantiated to obtain already known lambda calculi. Some properties which in the literature have been proved separately for different calculi can be proved once for the Parametric one. The lambda calculi are presented from a Computer Science point of view with a particular emphasis on their semantics both operational and denotational.

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