

Approximation algorithms

- Optimal algorithm too slow
- Heuristic algorithm too uncertain
- Provide result with guarantee:

$$\frac{|f_{OPT} - f|}{f_{OPT}} \leq \varepsilon$$

f = result of approximation algorithm

f_{OPT} = result of optimal algorithm

Approximation Algorithms

Vijay V. Vazirani



Approximation Algorithms:

Approximation Algorithms Vijay V. Vazirani, 2002-12-05 Covering the basic techniques used in the latest research work the author consolidates progress made so far including some very recent and promising results and conveys the beauty and excitement of work in the field He gives clear lucid explanations of key results and ideas with intuitive proofs and provides critical examples and numerous illustrations to help elucidate the algorithms Many of the results presented have been simplified and new insights provided Of interest to theoretical computer scientists operations researchers and discrete mathematicians

Approximation Algorithms Vijay V. Vazirani, 2013-03-14 Most natural optimization problems including those arising in important application areas are NP hard Therefore under the widely believed conjecture that $P \neq NP$ their exact solution is prohibitively time consuming Charting the landscape of approximability of these problems via polynomial time algorithms therefore becomes a compelling subject of scientific inquiry in computer science and mathematics This book presents the theory of approximation algorithms This book is divided into three parts Part I covers combinatorial algorithms for a number of important problems using a wide variety of algorithm design techniques Part II presents linear programming based algorithms These are categorized under two fundamental techniques rounding and the primal dual schema Part III covers four important topics the first is the problem of finding a shortest vector in a lattice the second is the approximability of counting as opposed to optimization problems the third topic is centered around recent breakthrough results establishing hardness of approximation for many key problems and giving new legitimacy to approximation algorithms as a deep theory and the fourth topic consists of the numerous open problems of this young field This book is suitable for use in advanced undergraduate and graduate level courses on approximation algorithms An undergraduate course in algorithms and the theory of NP completeness should suffice as a prerequisite for most of the chapters This book can also be used as supplementary text in basic undergraduate and graduate algorithms courses

Approximation Algorithms for Combinatorial Optimization Klaus Jansen, Jose Rolim, 1998-07 Computer simulation has become a basic tool in many branches of physics such as statistical physics particle physics or materials science The application of efficient algorithms is at least as important as good hardware in large scale computation This volume contains didactic lectures on such techniques based on physical insight The emphasis is on Monte Carlo methods introduction cluster algorithms reweighting and multihistogram techniques umbrella sampling efficient data analysis and optimization methods but aspects of supercomputing the solution of stochastic differential equations and molecular dynamics are also discussed The book addresses graduate students and researchers in theoretical and computational physics

The Design of Approximation Algorithms David P. Williamson, David B. Shmoys, 2011-04-26 Discrete optimization problems are everywhere from traditional operations research planning scheduling facility location and network design to computer science databases to advertising issues in viral marketing Yet most such problems are NP hard unless $P = NP$ there are no efficient algorithms to find optimal

solutions This book shows how to design approximation algorithms efficient algorithms that find provably near optimal solutions The book is organized around central algorithmic techniques for designing approximation algorithms including greedy and local search algorithms dynamic programming linear and semidefinite programming and randomization Each chapter in the first section is devoted to a single algorithmic technique applied to several different problems with more sophisticated treatment in the second section The book also covers methods for proving that optimization problems are hard to approximate Designed as a textbook for graduate level algorithm courses it will also serve as a reference for researchers interested in the heuristic solution of discrete optimization problems

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

Geometric Approximation Algorithms Sarel Har-Peled, 2011 Exact algorithms for dealing with geometric objects are complicated hard to implement in practice and slow Over the last 20 years a theory of geometric approximation algorithms has emerged These algorithms tend to be simple fast and more robust than their exact counterparts This book is the first to cover geometric approximation algorithms in detail In addition more traditional computational geometry techniques that are widely used in developing such algorithms like sampling linear programming etc are also surveyed Other topics covered include approximate nearest neighbor search shape approximation coresets dimension reduction and embeddings The topics covered are relatively independent and are supplemented by exercises Close to 200 color figures are included in the text to illustrate proofs and ideas

Design and Analysis of Approximation Algorithms Ding-Zhu Du, Ker-I Ko, Xiaodong Hu, 2011-11-18 This book is intended to be used as a textbook for graduate students studying theoretical computer science It can also be used as a reference book for researchers in the area of design and analysis of approximation algorithms Design and Analysis of Approximation Algorithms is a graduate course in theoretical computer science taught widely in the

universities both in the United States and abroad There are however very few textbooks available for this course Among those available in the market most books follow a problem oriented format that is they collected many important combinatorial optimization problems and their approximation algorithms and organized them based on the types or applications of problems such as geometric type problems algebraic type problems etc Such arrangement of materials is perhaps convenient for a researcher to look for the problems and algorithms related to his her work but is difficult for a student to capture the ideas underlying the various algorithms In the new book proposed here we follow a more structured technique oriented presentation We organize approximation algorithms into different chapters based on the design techniques for the algorithms so that the reader can study approximation algorithms of the same nature together It helps the reader to better understand the design and analysis techniques for approximation algorithms and also helps the teacher to present the ideas and techniques of approximation algorithms in a more unified way

Lectures on Proof Verification and Approximation Algorithms Ernst W. Mayr, Hans Jürgen Prömel, Angelika Steger, 2006-06-08 During the last few years we have seen quite spectacular progress in the area of approximation algorithms for several fundamental optimization problems we now actually know matching upper and lower bounds for their approximability This textbook like tutorial is a coherent and essentially self contained presentation of the enormous recent progress facilitated by the interplay between the theory of probabilistically checkable proofs and approximation algorithms The basic concepts methods and results are presented in a unified way to provide a smooth introduction for newcomers These lectures are particularly useful for advanced courses or reading groups on the topic

WALCOM: Algorithms and Computation Ryuhei Uehara, Katsuhisa Yamanaka, Hsu-Chun Yen, 2024-02-28 This book constitutes the refereed proceedings of the 18th International Conference and Workshops on Algorithms and Computation WALCOM 2024 held in Kanazawa Japan during March 18 20 2024 The 28 full papers presented in this book together with two extended abstracts of invited talks were carefully reviewed and selected from 80 submissions They cover diverse areas of algorithms and computation that is approximation algorithms algorithmic graph theory and combinatorics combinatorial algorithms combinatorial optimization computational biology combinatorial reconfiguration computational complexity computational geometry discrete geometry data structures experimental algorithm methodologies graph algorithms graph drawing parallel and distributed algorithms parameterized algorithms parameterized complexity network optimization online algorithms randomized algorithms and string algorithms

Approximation Algorithms for NP-hard Problems Dorit S. Hochbaum, 1997 This is the first book to fully address the study of approximation algorithms as a tool for coping with intractable problems With chapters contributed by leading researchers in the field this book introduces unifying techniques in the analysis of approximation algorithms APPROXIMATION ALGORITHMS FOR NP HARD PROBLEMS is intended for computer scientists and operations researchers interested in specific algorithm implementations as well as design tools for algorithms Among the techniques discussed the use of linear programming primal dual techniques in worst

case analysis semidefinite programming computational geometry techniques randomized algorithms average case analysis probabilistically checkable proofs and inapproximability and the Markov Chain Monte Carlo method The text includes a variety of pedagogical features definitions exercises open problems glossary of problems index and notes on how best to use the book **Lectures on Proof Verification and Approximation Algorithms** Ernst W. Mayr,Hans Jürgen

Prömel,Angelika Steger,1998-02-25 This is a self contained presentation of the enormous recent progress on the interplay between and applications of the theory of probabilistically checkable proofs and approximation algorithms **Key Concepts in Discrete Mathematics** Udayan Bhattacharya,2025-02-20 Key Concepts in Discrete Mathematics offers a comprehensive introduction to the fascinating realm of discrete mathematics covering a diverse array of topics essential for students and professionals in computer science mathematics engineering and related fields Through clear explanations illustrative examples and engaging exercises we provide readers with a solid foundation in discrete mathematics and its practical applications Our book covers a wide range of topics from fundamental concepts like sets relations and functions to advanced topics such as graph theory combinatorics and algorithm analysis We present complex concepts in a clear and accessible manner with detailed explanations and step by step examples guiding readers through each topic We emphasize practical applications and real world examples that demonstrate the relevance of discrete mathematics in various fields including computer science cryptography network theory and optimization Abundant exercises and problems ranging from basic to challenging allow readers to practice and reinforce their understanding of key concepts and techniques Additional online resources including solutions to selected exercises interactive quizzes and supplementary materials enhance the learning experience and provide opportunities for further exploration Whether used as a textbook in a classroom setting or as a self study guide Key Concepts in Discrete Mathematics serves as an invaluable resource for students seeking to deepen their understanding and for educators and professionals interested in exploring this essential area of mathematics

Approximation Algorithms for Combinatorial Optimization Klaus Jansen,Stefano Leonardi,Vijay Vazirani,2003-06-30 This book constitutes the refereed proceedings of the 5th International Workshop on Approximation Algorithms for Combinatorial Optimization Problems APPROX 2002 held in Rome Italy in September 2002 The 20 revised full papers presented were carefully reviewed and selected from 54 submissions Among the topics addressed are design and analysis of approximation algorithms inapproximability results online problems randomization techniques average case analysis approximation classes scheduling problems routing and flow problems coloring and partitioning cuts and connectivity packing and covering geometric problems network design and applications to game theory and other fields

Approximation Algorithms for Combinatorial Optimization Klaus Jansen,Samir Khuller,2003-07-31 This book constitutes the refereed proceedings of the Third International Workshop on Approximation Algorithms for Combinatorial Optimization Problems APPROX 2000 held in Saarbrücken Germany in September 2000 The 22 revised full papers presented together with

four invited contributions were carefully reviewed and selected from 68 submissions The topics dealt with include design and analysis of approximation algorithms inapproximability results on line problems randomization techniques average case analysis approximation classes scheduling problems routing and flow problems coloring and partitioning cuts and connectivity packing and covering geometric problems network design and various applications Handbook of Approximation Algorithms and Metaheuristics Teofilo F. Gonzalez, 2018-05-15 Handbook of Approximation Algorithms and Metaheuristics Second Edition reflects the tremendous growth in the field over the past two decades Through contributions from leading experts this handbook provides a comprehensive introduction to the underlying theory and methodologies as well as the various applications of approximation algorithms and metaheuristics Volume 1 of this two volume set deals primarily with methodologies and traditional applications It includes restriction relaxation local ratio approximation schemes randomization tabu search evolutionary computation local search neural networks and other metaheuristics It also explores multi objective optimization reoptimization sensitivity analysis and stability Traditional applications covered include bin packing multi dimensional packing Steiner trees traveling salesperson scheduling and related problems Volume 2 focuses on the contemporary and emerging applications of methodologies to problems in combinatorial optimization computational geometry and graphs problems as well as in large scale and emerging application areas It includes approximation algorithms and heuristics for clustering networks sensor and wireless communication bioinformatics search streams virtual communities and more About the Editor Teofilo F Gonzalez is a professor emeritus of computer science at the University of California Santa Barbara He completed his Ph D in 1975 from the University of Minnesota He taught at the University of Oklahoma the Pennsylvania State University and the University of Texas at Dallas before joining the UCSB computer science faculty in 1984 He spent sabbatical leaves at the Monterrey Institute of Technology and Higher Education and Utrecht University He is known for his highly cited pioneering research in the hardness of approximation for his sublinear and best possible approximation algorithm for k tMM clustering for introducing the open shop scheduling problem as well as algorithms for its solution that have found applications in numerous research areas as well as for his research on problems in the areas of job scheduling graph algorithms computational geometry message communication wire routing etc **Approximation**

Algorithms for Combinatorial Optimization, 2004 **Approximation Algorithms and Semidefinite Programming** Bernd Gärtner, Jiri Matousek, 2012-01-10 Semidefinite programs constitute one of the largest classes of optimization problems that can be solved with reasonable efficiency both in theory and practice They play a key role in a variety of research areas such as combinatorial optimization approximation algorithms computational complexity graph theory geometry real algebraic geometry and quantum computing This book is an introduction to selected aspects of semidefinite programming and its use in approximation algorithms It covers the basics but also a significant amount of recent and more advanced material There are many computational problems such as MAXCUT for which one cannot reasonably expect to obtain an exact solution

efficiently and in such case one has to settle for approximate solutions For MAXCUT and its relatives exciting recent results suggest that semidefinite programming is probably the ultimate tool Indeed assuming the Unique Games Conjecture a plausible but as yet unproven hypothesis it was shown that for these problems known algorithms based on semidefinite programming deliver the best possible approximation ratios among all polynomial time algorithms This book follows the semidefinite side of these developments presenting some of the main ideas behind approximation algorithms based on semidefinite programming It develops the basic theory of semidefinite programming presents one of the known efficient algorithms in detail and describes the principles of some others It also includes applications focusing on approximation algorithms

Approximation Algorithms for New Graph Partitioning and Facility Location Problems Zoya Svitkina, 2007 In applications as diverse as data placement in peer to peer systems control of epidemic outbreaks and routing in sensor networks the fundamental questions can be abstracted as problems in combinatorial optimization However many of these problems are NP hard which makes it unlikely that exact polynomial time algorithms for them exist Approximation algorithms are designed to circumvent this difficulty by finding provably near optimal solutions in polynomial time This thesis introduces a number of new combinatorial optimization problems that arise from various applications and proposes approximation algorithms for them These problems fall into two general areas graph partitioning and facility location The first problem that we introduce is the unbalanced graph cut problem Here the goal is to find a graph cut minimizing the size of one of the sides while also respecting an upper bound on the number of edges cut We develop two bicriteria approximation algorithms for this problem using the technique of Lagrangian relaxation and a different algorithm for its maximization version The other graph partitioning problem that we introduce and study is the min max multiway cut problem It aims to partition a graph into multiple components minimizing the maximum number of edges coming out of any component We present an approximation algorithm for this problem which uses unbalanced cuts as well as the greedy technique In the second part of the thesis we study two generalizations of the facility location problem which aims to open facilities assigning clients to them in order to minimize the facility opening costs and the connection costs In the facility location with hierarchical facility costs problem the facility costs are more general and depend on the set of assigned clients Our algorithm based on the local search technique uses two new local improvement operations achieving a constant factor approximation guarantee The second generalization is the load balanced facility location problem which specifies a lower bound for the number of clients assigned to an open facility We give the first true constant factor approximation algorithm which uses a reduction to the capacitated facility location problem The thesis is concluded with related open problems and directions for future research Abstract

Approximation, Randomization, and Combinatorial Optimization. Algorithms and Techniques Josep Diaz, Klaus Jansen, José D.P. Rolim, Uri Zwick, 2006-08-29 This is the joint refereed proceedings of the 9th International Workshop on Approximation Algorithms for Combinatorial Optimization Problems APPROX 2006 and the 10th International Workshop on Randomization

and Computation RANDOM 2006 The book presents 44 carefully reviewed and revised full papers Among the topics covered are design and analysis of approximation algorithms hardness of approximation problems small spaces and data streaming algorithms embeddings and metric space methods and more Approximation Algorithms for Network Design Problems
Adam W. Meyerson, 2002

The book delves into Approximation Algorithms. Approximation Algorithms is a vital topic that must be grasped by everyone, ranging from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into Approximation Algorithms, encompassing both the fundamentals and more intricate discussions.

1. This book is structured into several chapters, namely:
 - Chapter 1: Introduction to Approximation Algorithms
 - Chapter 2: Essential Elements of Approximation Algorithms
 - Chapter 3: Approximation Algorithms in Everyday Life
 - Chapter 4: Approximation Algorithms in Specific Contexts
 - Chapter 5: Conclusion
2. In chapter 1, this book will provide an overview of Approximation Algorithms. This chapter will explore what Approximation Algorithms is, why Approximation Algorithms is vital, and how to effectively learn about Approximation Algorithms.
3. In chapter 2, the author will delve into the foundational concepts of Approximation Algorithms. This chapter will elucidate the essential principles that need to be understood to grasp Approximation Algorithms in its entirety.
4. In chapter 3, this book will examine the practical applications of Approximation Algorithms in daily life. This chapter will showcase real-world examples of how Approximation Algorithms can be effectively utilized in everyday scenarios.
5. In chapter 4, the author will scrutinize the relevance of Approximation Algorithms in specific contexts. This chapter will explore how Approximation Algorithms is applied in specialized fields, such as education, business, and technology.
6. In chapter 5, this book will draw a conclusion about Approximation Algorithms. This chapter will summarize the key points that have been discussed throughout the book.

The book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of Approximation Algorithms.

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Approximation Algorithms Introduction

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