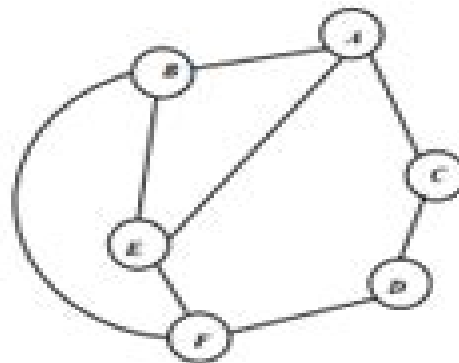You will be assigned one of the combinatorial search problems below; I will inform you by email.

- Given a graph $G = (V, E)$ and a positive integer $n \leq |V|$, determine whether there exists a subset $C \subseteq V$ whose cardinality $n$ such that every two vertices in $C$ are connected by an edge in $E$.

- Given a graph $G$ and a nonnegative integer $n \leq |V|$, determine there exists a subset $C \subseteq V$ whose cardinality $n$ such that, for every edge $\{x, y\}$ in $E$, $x$ or $y$ is in $C$.

1. Represent the assigned problem in propositional logic by a set of formulae in an understandable way, for the following graph and for $n = 3$ and $n = 4$.



2. Transform this propositional theory into CNF format.

3. Transform the CNF formulae into DIMACS CNF format.

4. Find an interpretation satisfying these formulae, using a SAT solver.

You are expected to submit a 3-slide presentation at SUCourse+, one slide for each part (1)–(4), and to make a demo of your solution.

# Combinatorial Search Problems

**Yury V. Smirnov,Carnegie-mellon univ pittsburgh pa Dept. of computer science**

**Combinatorial Search Problems:**

State-Space Search Weixiong Zhang,2012-12-06 This book is about problem solving Specifically it is about heuristic state space search under branch and bound framework for solving com binatorial optimization problems The two central themes of this book are the average case complexity of heuristic state space search algorithms based on branch and bound and their applications to developing new problem solving methods and algorithms Heuristic state space search is one of the fundamental problem solving techniques in Computer Science and Operations Research and usually constitutes an important component of most intelligent problem solving systems The search algorithms considered in this book can be classified into the category of branch and bound Branch and bound is a general problem solving paradigm and is one of the best techniques for optimally solving computation intensive problems such as scheduling and planning The main search algorithms considered include best first search depth first branch and bound iterative deepening recursive best first search and space bounded best first search Best first search and depth first branch and bound are very well known and have been used extensively in Computer Science and Operations Research One important feature of depth first branch and bound is that it only requires space this is linear in the maximal search depth making it very often a favorable search algo rithm over best first search in practice Iterative deepening and recursive best first search are the other two linear space search algorithms Iterative deepening is an important algorithm in Artificial Intelligence and plays an irreplaceable role in building a real time game playing program **Combinatorial Search: From Algorithms to Systems** Youssef Hamadi,2013-10-29 Although they are believed to be unsolvable in general tractability results suggest that some practical NP hard problems can be efficiently solved Combinatorial search algorithms are designed to efficiently explore the usually large solution space of these instances by reducing the search space to feasible regions and using heuristics to efficiently explore these regions Various mathematical formalisms may be used to express and tackle combinatorial problems among them the constraint satisfaction problem CSP and the propositional satisfiability problem SAT These algorithms or constraint solvers apply search space reduction through inference techniques use activity based heuristics to guide exploration diversify the searches through frequent restarts and often learn from their mistakes In this book the author focuses on knowledge sharing in combinatorial search the capacity to generate and exploit meaningful information such as redundant constraints heuristic hints and performance measures during search which can dramatically improve the performance of a constraint solver Information can be shared between multiple constraint solvers simultaneously working on the same instance or information can help achieve good performance while solving a large set of related instances In the first case information sharing has to be performed at the expense of the underlying search effort since a solver has to stop its main effort to prepare and commu nicate the information to other solvers on the other hand not sharing information can incur a cost for the whole system with solvers potentially exploring unfeasible spaces discovered by other solvers In the second case sharing performance measures can be

done with little overhead and the goal is to be able to tune a constraint solver in relation to the characteristics of a new instance this corresponds to the selection of the most suitable algorithm for solving a given instance The book is suitable for researchers practitioners and graduate students working in the areas of optimization search constraints and computational complexity **On Algorithm Selection, with an Application to Combinatorial Search Problems** Lars Kotthoff,University of St. Andrews. Department of Computer Science,Engineering and Physical Sciences Research Council,Scottish Informatics and Computer Science Alliance,2012 **Principles and Practice of Constraint Programming - CP '95** Ugo Montanari,1995-09-06 This book constitutes the proceedings of the First International Conference on Principles and Practice of Constraint Programming CP 95 held in Cassis near Marseille France in September 1995 The 33 refereed full papers included were selected out of 108 submissions and constitute the main part of the book in addition there is a 60 page documentation of the four invited papers and a section presenting industrial reports Thus besides having a very strong research component the volume will be attractive for practitioners The papers are organized in sections on efficient constraint handling constraint logic programming concurrent constraint programming computational logic applications and operations research **Search Problems** Rudolf Ahlswede,Ingo Wegener,1987-12-28 Introductory remarks and definitions A sample search model Search problems with error free tests Binary search problems without restrictions on the tests Alphabetic codes and binary search trees Sorting problems Weighting problems and geometric problems Special search problems with error free tests Search problems having tests with chance errors Stochastic approximation Search problem having answers with chance errors and channels with feedback Identification and ranking problems Search problems with inspections Minimizing expected search costs Maximizing the probability of sucess with limited resources More general models for search problems with inspection *Algorithms - ESA '97* Rainer Burkard,Gerhard Woeginger,1997-08-27 This book constitutes the refereed proceedings of the 5th Annual International European Symposium on Algorithms ESA 97 held in Graz Austria September 1997 The 38 revised full papers presented were selected from 112 submitted papers The papers address a broad spectrum of theoretical and applicational aspects in algorithms theory and design Among the topics covered are approximation algorithms graph and network algorithms combinatorial optimization computational biology computational mathematics data compression distributed computing evolutionary algorithms neural computing online algorithms parallel computing pattern matching and others **State Space Search** Fouad Sabry,2023-06-28 What Is State Space Search State space search is a technique that is employed in the field of computer science particularly artificial intelligence AI in which consecutive configurations or states of an instance are explored with the objective of finding a goal state with the desired feature The term state space search comes from the phrase state space which refers to the space in which the process takes place How You Will Benefit I Insights and validations about the following topics Chapter 1 State Space Search Chapter 2 Brute Force Search Chapter 3 Heuristic in Computer

Science Chapter 4 Local Search Optimization Chapter 5 Game Tree Chapter 6 Constraint Satisfaction Problem Chapter 7 Adversarial Search Chapter 8 Markov Decision Process Chapter 9 Reinforcement Learning Chapter 10 Combinatorial search II Answering the public top questions about state space search III Real world examples for the usage of state space search in many fields IV 17 appendices to explain briefly 266 emerging technologies in each industry to have 360 degree full understanding of state space search technologies Who This Book Is For Professionals undergraduate and graduate students enthusiasts hobbyists and those who want to go beyond basic knowledge or information for any kind of state space search

**Reactive Search and Intelligent Optimization** Roberto Battiti,Mauro Brunato,Franco Mascia,2008-12-16 Reactive Search and Intelligent Optimization is an excellent introduction to the main principles of reactive search as well as an attempt to develop some fresh intuition for the approaches The book looks at different optimization possibilities with an emphasis on opportunities for learning and self tuning strategies While focusing more on methods than on problems problems are introduced wherever they help make the discussion more concrete or when a specific problem has been widely studied by reactive search and intelligent optimization heuristics Individual chapters cover reacting on the neighborhood reacting on the annealing schedule reactive prohibitions model based search reacting on the objective function relationships between reactive search and reinforcement learning and much more Each chapter is structured to show basic issues and algorithms the parameters critical for the success of the different methods discussed and opportunities forthe automated tuning of these parameters **Entropy, Search, Complexity** Imre Csiszár,Gyula O.H. Katona,Gabor Tardos,2007-04-05 The present volume is a collection of survey papers in the elds given in the title They summarize the latest developments in their respective areas More than half of the papers belong to search theory which lies on the borderline of mathematics and computer science information theory and combinatorics respectively The volume is slightly related to the twin conferences Search And Communication Complexity and Information Theory In Mathematics held at Balatonlelle Hungary in 2000 These conferences led us to believe that there is a need for such a collection of papers The paper written by Martin Aigner starts with the following relatively new search problem Given n boolean variables as input one has to nd one of them whose value is in majority The goal is to minimize the number of tests needed for this where one test is to compare two input variables for equality The paper surveys the large set of problems and results which grew out of this one In the traditional search model an unknown element is sought in a nite set based on the information that the unknown element is or is not in some asked subsets A variant is when a 0 1 function is given on the underlying set and only the values of this function at the unknown element x is sought rather than x itself This is called the recognition problem Parallel Algorithm and Computation Virendra Kumar, This book comprises all the aspects like principle and techniques for parallel algorithm Parallel processing system for B Tech MCA M Tech Students of computer science and engineering information technology This book consist the syllabus of all Indian Universities It also provides the basic concepts of parallel algorithm and computations **Local**

**Search Algorithms for Combinatorial Problems** Thomas G. Stutzle,1999-01-01 Many problems of enormous practical and theoretical importance are of combinatorial nature Combinatorial problems are intriguing because they are easy to state but many of them are very difficult to solve they are NP hard Local search and extensions thereof based on metaheuristics which have been developed at the interface between Artificial Intelligence and Operations Research are among the best available techniques for obtaining high quality solutions to large instances of NP hard problems in a reasonable time This book presents contributions to several research aspects of metaheuristics The contributions concern i the introduction of a new methodology for analyzing the run time behavior of metaheuristics and in general randomized algorithms ii the derivation of improved algorithmic variants for known metaheuristics in particular for ant colony optimization and iterated local search iii the exploration of new applications of specific metaheuristics and iv the characterization of the run time behavior of specific metaheuristics The achievements described in this book can be regarded as a further step towards achieving the goals of research on metaheuristics the development of general and flexible but at the same time powerful and efficient algorithms to approximately solve hard combinatorial problems **On Algorithm Selection, with an Application to Combinatorial Search Problems** Lars Kotthoff,2012 **1993 Computer Architectures for Machine Perception** Magdy A. Bayoumi,Larry S. Davis,Kimon Valavanis,1993 Proceedings of the Computer Architectures for Machine Perception Workshop held Dec 15 17 1993 in New Orleans Louisiana Papers came from several communities computer architecture pattern recognition image processing and analysis computer vision and VLSI No index Annotation copyright Book N Hybrid Algorithms for On-Line Search and Combinatorial Optimization Problems Yury V. Smirnov,Carnegie-mellon univ pittsburgh pa Dept. of computer science,1997 Abstract By now Artificial Intelligence AI Theoretical Computer Science CS theory and Operations Research OR have investigated a variety of search and optimization problems However methods from these scientific areas use different problem descriptions models and tools They also address problems with particular efficiency requirements For example approaches from CS theory are mainly concerned with the worst case scenarios and are not focused on empirical performance A few efforts have tried to apply methods across areas Usually a significant amount of work is required to make different approaches talk the same language be successfully implemented and finally solve the actual same problem with an overall acceptable efficiency This thesis presents a systematic approach that attempts to advance the state of the art in the transfer of knowledge across the above mentioned areas In this work we investigate a number of problems that belong to or are close to the intersection of areas of interest of AI OR and CS theory We illustrate the advantages of considering knowledge available in different scientific areas and of applying algorthms sic across distinct disciplines through successful applications of novel hybrid algorithms that utilize benefitial sic features of known efficient approaches Testbeds for such applications in this thesis work include both open theoretical problems and ones of significant practical importance We introduce a representation change that enables us to question the relation between the Pigeonhole

Principle and Linear Programming Relaxation We show that both methods have exactly the same bounding power Furthermore even stronger relation appears to be between the two methods The Pigeonhole Principle is the Dual of Linear Programming Relaxation Such a relation explains the hidden magic of the Pigeonhole Principle namely its power in establishing upper bounds and its effectiveness in constructing optimal solutions We also address various groups of problems that arise in agent centered search In particular we consider goal directed exploration in which search by a physical or fictitious agent with limited lookahead occurs in partially or completely unknown domains The resulting Variable Edge Cost Algorithm VECA becomes the first method of solving goal directed exploration problems that incorporates strong guidance from heuristic knowledge yet is still capable of providing linear worst case guarantees even for complex search domains and misleading heuristics This work aims at expanding the handset of AI tools that concern search efficiency and provides the foundation for further development of hybrid methods cross fertilization and successful applications across AI CS theory OR and other Computational Sciences       **Local Search for NP-Hard Problems** Jeremy David Frank,1997       **Parallel Algorithms for Combinatorial Search Problems** Yanjun Zhang,1989 Abstract This thesis is a theoretical study of parallel algorithms for combinatorial search problems In this thesis we present parallel algorithms for backtrack search branch and bound computation and game tree search Our model of parallel computation is a network of processors communicating via messages Our primary interest in a parallel algorithm is its speed up over the sequential ones Our goal is to design parallel algorithms that achieve a speed up proportional to the number of processors used We first study backtrack search that enumerates all solutions to a combinatorial problem We propose a simple randomized method for parallelizing sequential backtrack search algorithms for solving enumeration problems       *Local Search in Combinatorial Optimization* Emile H. L. Aarts,Jan Karel Lenstra,2003-08-03 1 Introduction 2 Computational complexity 3 Local improvement on discrete structures 4 Simulated annealing 5 Tabu search 6 Genetic algorithms 7 Artificial neural networks 8 The traveling salesman problem A case study 9 Vehicle routing Modern heuristics 10 Vehicle routing Handling edge exchanges 11 Machine scheduling 12 VLSI layout synthesis 13 Code design       *Proceedings* ,1993       **Proceedings of the Workshop on Physics and Computation** ,1994       **Modern Heuristic Techniques for Combinatorial Problems** C. R. Reeves,1993-05-11 Experienced researchers describe the latest types of heuristic procedures Artificial networks simulated annealing Tabu search Lagrangean relaxation genetic algorithms and evaluation of heuristics are among the subjects discussed

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