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Book Review

Handbook of Combinatorial Optimization DingZhu Du and Panos M. Pardalos (co-editors), Kluwer Academic Publishers, 1998, Vols. 1–3, ISBN: 0-7923-5285-8

Combinatorial optimization is one of the most active fields in the interface of operations, computer science, and applied mathematics. Combinatorial optimization problems arise in various applications, including communication network design, VLSI design, machine vision, airline crew scheduling, corporate planning, computer-aided design and manufacturing, database query design, cellular telephone frequency assignment, constraint directed reasoning, and computational biology.

This Handbook represents the most comprehensive handbook in the field of combinatorial optimization. Written by active researchers in the field, each chapter in the Handbook is essentially expository in nature, but of scholarly treatment. The Handbook is addressed not only to researchers in discrete optimization, but to all scientists in various disciplines who use combinatorial optimization methods to model and solve problems. Experts in the field as well as nonspecialists will find the material stimulating and helpful. The following gives a brief description of each of the chapters contained in the first three volumes of this handbook. Information about a supplement volume of this Handbook can be found at http://www.wkap.nl/book.htm/0-7923-5924-0.

- Vol. 1, pp. 1–76; C.S. Adjiman, C.A. Schweiger and C.A. Floudas, *Mixed-integer nonlinear optimization in process synthesis*.
  The treatment of a particular class of network applications, the *process synthesis problem*, is exposed in this paper. A number of local optimization algorithms, developed for the solution of this class of problem, are presented in this paper. 52 references.
- Vol. 1, pp. 77–148, R. Battiti and M. Protasi, *Approximate algorithms and heuristics for MAX-SAT*.
  This paper provides an overview of some basic approaches for the exact or approximated solution of the MAX W-SAT and MAX-SAT problems. 84 references.
- Vol. 1, pp. 149–188, F. Giannessi and F. Tardella, *Connections between nonlinear programming and discrete optimization*.

This paper discusses relations between discrete optimization problems and their continuous relaxations. Some general techniques and their applications are presented here. 71 references.

- Vol. 1, pp. 189–297, J.E. Michell, P.M. Pardalos and M.G.C. Resende, *Interior point methods for combinatorial optimization*.

  This paper describes the conceptual basis and applications of interior-point methods for discrete problems in computing. It explains the nature and scope of combinatorial optimization problems and illustrate the use of interior point approaches for these problems. 152 references.
- Vol. 1, pp. 299–428, D. Pisinger and P. Toth, *Knapsack problems*.
  Several variants of the classical 0-1 knapsack problem are considered with respect to relaxations, bounds, reductions and other algorithmic techniques for the exact solution. Computational results are presented to compare the actual performance of the most effective algorithms published. 118 references.
- Vol. 1, pp. 429–478, T. Radzik, *Fractional combinatorial optimization*.

  This paper is focused on two main methods for fractional combinatorial optimization, the Newton method and Megiddos's parametric search method. It also discusses applications to the maximum profit-to-time ratio cycles problem, the maximum mean cycles problem and the maximum mean-weight cuts problem. 49 references.
- Vol. 1, pp. 479–532, H.D. Sherali and W.P. Adams, *Reformulation-linearization techniques for discrete optimization problems*.

  This paper addresses the issue of generating tight linear programming representations via automatic reformulation techniques in solving discrete mixed-integer linear programming problems. The particular approach that the authors focus on is called reformulation linearization technique, a procedure that can be used to generate tight linear or convex programming representations, for constructing not only exact solution algorithms, but also to design powerful heuristic procedures. 64 references.
- Vol. 1, pp. 533–572, R.R. Thomas, *Gröbner bases in integer programming*.

  Recently, applications of the theory of Gröbner bases to integer programming has given rise to new tools and results in this field. This paper presents this algebraic theory as the natural integer analog of the simplex approach to linear programming. 33 references.
- Vol. 1, pp. 573–746, R.R. Vemuganti, *Applications of set covering, set packing and set partitioning modes: a survey*.

  This paper is a survey of the applications of the set covering, set packing models and their variants, including generalizations. Applications include personnel scheduling, crew scheduling, manufacturing, routing, location, and miscellaneous operations. Over 800 references.
- Vol. 2, pp. 1–33, D.Z. Chen, *Efficient algorithms for geometric shortest path query problems*.

This paper covers the newly-developed algorithmic paradigms for processing geometric shortest path queries and related problems. These general paradigms have led to efficient techniques for designing algorithms and data structures for processing a variety of queries on exact and approximate shortest paths in a number of geometric and graphical settings. Some open problems and promising directions for future research are also discussed. 76 references.

- Vol. 2, pp. 35–76, B. DasGupta, X. He, T. Jiang, M. Li, J. Tromp, L. Wang and L. Zhang, *Computing distances between evolutionary trees*.

  Comparing objects to find their similarities or, equivalently, dissimilarities, is a fundamental issue in many fields including pattern recognition, image analysis, drug design, the study of thermodynamic costs of computing, cognitive science, etc. The degree of similarity is often referred to as the distance. While some distances are easy to compute, others (such as transformation based) are not. In this paper, the authors survey recent results on some transformation based distances for evolutionary trees. 49 references.

- Vol. 2, pp. 77–103, X. Deng, *Combinatorial optimization and coalition games*.

  Studies on games in coalition form deal with the power of cooperation among its participants. In this sense it is often referred to as cooperative game theory. The field of combinatorial optimization has much to offer for the study of cooperative games. In this paper, the author discusses some progress in combinatorial optimization games, in particular, those involved with computational complexity issues. Several open problems are raised where the corresponding problems are discussed. 62 references.

- Vol. 2, pp. 105–157, F.C. Harris, Jr., *Steiner minimal trees: an introduction, parallel computation, and future work*.

  This paper presents several algorithms for calculating Steiner minimal trees, including the first parallel algorithm for doing so. Several implementation issues are discussed, some new results are presented, and several ideas for future work are proposed. 52 references.

- Vol. 2, pp. 159–260, N. Katoh and T. Ibaraki, *Resource allocation problems*.

  The resource allocation problem seeks to find an optimal allocation of a fixed amount of resources to activities so as to minimize the cost incurred by the allocation. This problem is encountered in a variety of application areas, including load distribution, production planning, computer resource allocation, queuing control, portfolio selection, and apportionment. This paper gives an overview of the recent progress on the theory and applications, putting emphasis on the cases with discrete variables. 123 references.

- Vol. 2, pp. 261–329, B. Mirkin and I. Muchnik, *Combinatorial optimization in clustering*.

  Combinatorial optimization and graph theory are closely connected with clustering issues through such combinatorial concepts as connected component, clique, graph coloring, min-cut, and location problems having obvious cluster-

ing flavor. This paper gives an overview of many combinatorial optimization algorithms and their applications in clustering. 81 references.

- Vol. 2, pp. 331–395, P.M. Pardalos, T. Mavridou and J. Xue, *The graph coloring problem: a bibliographic survey*.
  This paper presents an overview of recent results on graph coloring with an extensive bibliographic survey. 511 references.
- Vol. 2, pp. 397–470, J.M. Smith, *Steiner minimal trees in E^3: theory, algorithms, and applications*.
  This paper presents algorithms for the Steiner minimal trees in E^3 in great details. Important applications, such as protein modeling, are also discussed here. 68 references.
- Vol. 2, pp. 471–524, J. Starke and M. Schanz, *Dynamical system approaches to combinatorial optimization*.
  This paper describes and compares several dynamical system approaches to combinatorial optimization problems. These include penalty methods, the approach of Hopfield and Tank, self-organizing maps, and many others. Many of them are investigated analytically and the costs of the solutions are compared numerically with those of solutions obtained by simulated annealing and the costs of a global optimal solution. 91 references.
- Vol. 2, pp. 525–542, W.G. Tzeng, *On-line dominating set problems for graphs*.
  This paper presents on-line algorithms for dominating sets of general and permutation graphs under various on-line settings. Open problems for future in this area are also discussed here. 19 references.
- Vol. 2, pp. 543–588, P.J. Wan, *Optimization problems in optical networks*.
  This paper gives an overview of routing and wavelength assignment in wavelength division multiplexed (WDM) networks. Many open problems with applications to optical networks are discussed here. 64 references.
- Vol. 2, pp. 589–616, J.F. Weng, *Shortest networks on surfaces*.
  This paper give an overview of the Steiner tree problem on curved surfaces. In particular, it discusses the Steiner tree problem on Spheres, the Steiner ratio on spheres and other related problems. 19 references.
- Vol. 2, pp. 617–634, Y.F. Xu, *Minimum weight triangulation*.
  This paper provides a survey of recent results on the minimum weight triangulation problem. Several open problems in this area are also discussed here. 54 references.
- Vol. 2, pp. 635–726, G. Yu and J. Yang, *Optimization applications in the airline industry*.
  In this paper, the authors survey the major optimization areas that have had a great impact on the airline industry. The topics covered include network design, yield management, flight planning and fleet assignment, crew scheduling, air traffic flow control, and irregular operations control. Future research topics in these areas are also addressed here. 164 references.

- Vol. 3, pp. 1–19, D. Bertsimas and Y. Ye, *Semidefinite relaxations, multivariate normal distributions, and order statistics*.
  Semidefinite programming relaxations to hard combinatorial optimization problems have led to several important results recently, e.g. the better approximation for max-cut by Goemans and Williamson. This paper presents several better approximation algorithms to cut related optimization problems using new randomization techniques. Computational results supporting the theory are also reported here. 17 references.
- Vol. 3, pp. 21–169, B. Chen, C.N. Potts and G.J. Woeginger, *A review of machine scheduling: complexity, algorithms and approximability*.
  This paper surveys research on deterministic machine scheduling. The survey includes statements of complexity results, descriptions of enumerative algorithms together with an indication of the size of instances that they might reasonably be expected to solve, the main features of local search methods including an indication of their ability to generate near-optimal solutions, and details of performance guarantees for approximation algorithms. 574 references.
- Vol. 3, pp. 171–239, F. Cao, *Routing and topology embedding in lightwave networks*.
  Many research issues in wavelength division multiplexed (WDM) networks can be transformed into combinatorial optimization problems. This paper discuss problems such as routing and virtual topology embeddings to support high performance distributed computing, reliable routing, and tunable transmissions. 59 references.
- Vol. 3, pp. 241–337, R.E. Burkard, E. Cela, P.M. Pardalos and L.S. Pitsoulis, *The quadratic assignment problem*.
  This paper provides an extensive survey of recent results in the study of the quadratic assignment problem and its applications. 177 references.
- Vol. 3, pp. 339–405, G.J. Chang, *Algorithmic aspects of domination in graphs*.
  This paper provides a survey of the domination problem in graph theory, which is a natural model for many location problems in operations research, from an algorithmic point of view. 181 references.
- Vol. 3, pp. 407–456, R.C. Correa, A. Ferreira and S.C.S. Porto, *Selected algorithmic techniques for parallel optimization*.
  This paper presents a review of the literature pertinent to design and implementation of parallel algorithms for discrete optimization problems. The focus is on distributed memory parallel systems. 79 references.
- Vol. 3, pp. 457–541, J. Gu, *Multispace search for combinatorial optimization*.
  This paper presents the multispace search method for combinatorial optimization problems. Applications the graph partitioning problem, the TSP problem, and the scheduling and task assignment problem are discussed here. 113 references.
- Vol. 3, pp. 543–566, K.W. Lih, *The equitable coloring of graphs*.

This paper surveys recent progress on the equitable coloring of graphs. Attention is paid to work done on the equitable Δ-coloring conjecture. Related graph coloring problems and future research topics are also discussed here. 28 references.

- Vol. 3, pp. 567–620, S. Rajasekaran and J.D.P. Rolim, *Randomized parallel algorithms for combinatorial optimization*.
  In this paper, the authors present some important randomization techniques for the parallel processing of discrete problems including sorting, packet routing, shortest path and matching problems. The authors also discuss the connection between randomization and approximation and demonstrate this by means of network flow problems. 77 references.
- Vol. 3, pp. 612–757, F. Glover, *Tabu search*.
  The designer of the meta-heuristic known as Tabu Search gives a comprehensive review of the technique and applications of Tabu Search. 73 references.

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