Chapter 1 : Mathematical optimization - Wikipedia

"A First Course in Combinatorial Optimization" is a self-contained text for a one-semester introductory graduate-level course for students of operations research, mathematics, and computer science.

Multi-objective optimization Adding more than one objective to an optimization problem adds complexity. For example, to optimize a structural design, one would desire a design that is both light and rigid. When two objectives conflict, a trade-off must be created. There may be one lightest design, one stiffest design, and an infinite number of designs that are some compromise of weight and rigidity. The set of trade-off designs that cannot be improved upon according to one criterion without hurting another criterion is known as the Pareto set. The curve created plotting weight against stiffness of the best designs is known as the Pareto frontier. A design is judged to be "Pareto optimal" equivalently, "Pareto efficient" or in the Pareto set if it is not dominated by any other design: If it is worse than another design in some respects and no better in any respect, then it is dominated and is not Pareto optimal. The choice among "Pareto optimal" solutions to determine the "favorite solution" is delegated to the decision maker. In other words, defining the problem as multi-objective optimization signals that some information is missing: In some cases, the missing information can be derived by interactive sessions with the decision maker. Multi-objective optimization problems have been generalized further into vector optimization problems where the partial ordering is no longer given by the Pareto ordering. Multi-modal optimization[edit] Optimization problems are often multi-modal; that is, they possess multiple good solutions. They could all be globally good same cost function value or there could be a mix of globally good and locally good solutions. Obtaining all or at least some of the multiple solutions is the goal of a multi-modal optimizer. Classical optimization techniques due to their iterative approach do not perform satisfactorily when they are used to obtain multiple solutions, since it is not guaranteed that different solutions will be obtained even with different starting points in multiple runs of the algorithm. Evolutionary algorithms , however, are a very popular approach to obtain multiple solutions in a multi-modal optimization task. Classification of critical points and extrema[edit] Feasibility problem[edit] The satisfiability problem , also called the feasibility problem, is just the problem of finding any feasible solution at all without regard to objective value. This can be regarded as the special case of mathematical optimization where the objective value is the same for every solution, and thus any solution is optimal. Many optimization algorithms need to start from a feasible point. One way to obtain such a point is to relax the feasibility conditions using a slack variable ; with enough slack, any starting point is feasible. Then, minimize that slack variable until slack is null or negative. Existence[edit] The extreme value theorem of Karl Weierstrass states that a continuous real-valued function on a compact set attains its maximum and minimum value. More generally, a lower semi-continuous function on a compact set attains its minimum; an upper semi-continuous function on a compact set attains its maximum. More generally, they may be found at critical points , where the first derivative or gradient of the objective function is zero or is undefined, or on the boundary of the choice set. Optima of equality-constrained problems can be found by the Lagrange multiplier method. Sufficient conditions for optimality[edit] While the first derivative test identifies points that might be extrema, this test does not distinguish a point that is a minimum from one that is a maximum or one that is neither. When the objective function is twice differentiable, these cases can be distinguished by checking the second derivative or the matrix of second derivatives called the Hessian matrix in unconstrained problems, or the matrix of second derivatives of the objective function and the constraints called the bordered Hessian in constrained problems. If a candidate solution satisfies the first-order conditions, then satisfaction of the second-order conditions as well is sufficient to establish at least local optimality. Sensitivity and continuity of optima[edit] The envelope theorem describes how the value of an optimal solution changes when an underlying parameter changes. The process of computing this change is called comparative statics. The maximum theorem of Claude Berge describes the continuity of an optimal solution as a function of underlying parameters. Calculus of optimization[edit] See also: More generally, a zero subgradient certifies that a local minimum has been found for minimization problems with convex functions and other locally Lipschitz functions. Further, critical points can be classified using the definiteness of the Hessian matrix: If the Hessian is positive definite at a critical point, then the point is a local minimum; if the Hessian matrix is negative definite, then the point is a local maximum; finally, if indefinite, then the point is some kind of saddle point. Constrained problems can often be transformed into unconstrained problems with the help of Lagrange multipliers. Lagrangian relaxation can also provide approximate solutions to difficult constrained problems. When the objective function is convex , then any local minimum will also be a global minimum. There exist efficient numerical techniques for minimizing convex functions, such as interior-point methods. Computational optimization techniques[edit] To solve problems, researchers may use algorithms that terminate in a finite number of steps, or iterative methods that converge to a solution on some specified class of problems , or heuristics that may provide approximate solutions to some problems although their iterates need not converge.

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Chapter 2 : Combinatorial optimization - Wikipedia

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We study the problem of optimizing nonlinear objective functions over matroids presented by oracles or explicitly. Such functions can be interpreted as the balancing of multi-criteria optimization. We provide a combinatorial polynomial time algorithm for arbitrary oracle-presented matroids, that mak We provide a combinatorial polynomial time algorithm for arbitrary oracle-presented matroids, that makes repeated use of matroid intersection, and an algebraic algorithm for vectorial matroids. Our work is partly motivated by applications to minimum-aberration model-fitting in experimental design in statistics, which we discuss and demonstrate in detail. We address optimization of nonlinear functions of the form f Wx , where f: Generally, such problems are intractable, so we obtain positive algorithmic results by looking a Generally, such problems are intractable, so we obtain positive algorithmic results by looking at broad natural classes of f, W and F. One of our main motivations is multi-objective discrete optimization, where f trades off the linear functions given by the rows of W. Another motivation is that we want to extend as much as possible the known results about polynomial-time linear optimization over trees, assignments, matroids, polymatroids, etc. We assume that the convex hull of F is well-described by linear inequalities i. For example, the set of characteristic vectors of common bases of a pair of matroids on a common ground set satisfies this property for F. We consider a special class of the multi-linear forms studied by Brascamp and Lieb. For these forms, we are able to characterize the L p spaces for which the form is bounded. We use this characterization to study a non-linear map that arises in scattering theory. Multi-linear interpolation Mathematics subject classification: The matroid polytope can also be described by a set of inequalities and we are able to use this description to establish our estimates. We will use two operations on sets in matroids. De Loera, David C. Haws, Jon Lee " Motivated by recent work on algorithmic theory for nonlinear and multicriteria matroid optimization, we have developed algorithms and heuristics aimed at practical solution of large instances of some of these difficult problems. Our methods primarily use the local adjacency structure inherent in mat Our methods primarily use the local adjacency structure inherent in matroid polytopes to pivot to feasible solutions which may or may not be optimal. We also present a modified breadth-first-search heuristic that uses adjacency to enumerate a subset of feasible solutions. We present other heuristics, and provide computational evidence supporting our techniques. Weismantel, Yael Berstein, Jon Lee "

Chapter 3 : A First Course in Combinatorial Optimization by Jon Lee

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Chapter 4 : A First Course in Combinatorial Optimization - Jon Lee - Google Books

A First Course in Combinatorial Optimization is a text for a one-semester introductory graduate-level course for students of operations research, mathematics, and computer science. It is a self-contained treatment of the subject, requiring only some mathematical maturity.

Chapter 5 : Editions of A First Course in Combinatorial Optimization by Jon Lee

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A First Course in Combinatorial Optimization is a textbook designed for a one-semester introduction at the first year graduate level. It is aimed at students of mathematics, computer science, and operations research.

Chapter 7 : Discrete optimization - Wikipedia

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