Review

Integrated methods for optimization (2nd ed.)
Hooker J., Springer Publishing Company, Incorporated, New York, NY, 2012. 658 pp.
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Full Text

The author has an explicit ideological agenda--to integrate major approaches to solving optimization problems--but transcends ideology by stressing problem solving driven by the structure of the problem. The book amply illustrates the power of combining the strengths of constraint programming, mathematical programming, global optimization, and heuristics by detailing these approaches, by articulating the commonalties among them, and by applying them to a wide range of optimization problems.

The book opens with a chapter introducing the theory that drives what follows, which briefly but persuasively justifies that theory. The operating premise is that a scheme that integrates search, inference, and relaxation, three major approaches that are often applied separately, allows a problem to be solved by calibrating the approach to the problem's structure. The problem has priority, not the method of solving it. The author particularly notes that duality, which is a major approach to optimization, can be categorized as either inference or relaxation, which strengthens the rationale for the integrated approach.

Following the introduction is a chapter that represents the intellectual heart of the book. It presents seven concrete optimization problems and solves them using the integrated approach of search, inference, and relaxation. For example, a classic optimization problem has variables of different trucks with different capacities and with different costs. The book formulates the problem in typical linear programming notation, but solves it using two forms of inference and one form of relaxation using linear programming. The solutions are succinct and complemented by references to the literature. Readers wanting more information about the methodology of the book can gain it from this chapter alone. It serves as an excellent, practical illustration for what follows.

The third chapter is devoted to a survey of optimization basics that covers linear and nonlinear programming, network flows, and dynamic programming. In the course of the discussion, optimality and feasibility conditions, sensitivity analysis, state variables, and complexity are treated with precision and clarity. The chapter serves as a theoretical complement to the practical problems treated in the second chapter.

The next four chapters elaborate on methods discussed earlier: duality, search, inference, and relaxation. Each topic receives a chapter-length treatment that elaborates the topic and provides an appropriate level of detail to supplement the necessarily briefer treatments in earlier chapters. These chapters are by far the most rigorous and complex in the book, and each provides a substantial treatment that equips practitioners with a thorough grounding in theory. They do not, however, address problem solving with real-world examples. The application of the theory is left to the practitioners.

The chapter on duality makes the case that, because duality connects search with inference and relaxation, it is central to the integration of optimization methods. The chapter covers such aspects as weak and strong duality, constraint-directed search, relaxation, linear programming, the dual simplex method, and Lagrangean duality. The chapter details, for example, how linear programming can be seen as inference or relaxation duals.

The chapter on search covers branching, constraint-directed search, and incomplete search. Each approach is developed in detail, and the utility of each approach is

demonstrated with an example. The example related to constraint-directed searching is, as the author notes, artificial, in contrast to the two other examples, which are close to real-world problems. A similar more practical example would be useful.

The chapter on inference, which accounts for approximately one quarter of the entire narrative section of the book, is especially well developed in covering, among other topics, linear inequalities, propositional logic, numerous types of constraints, and both disjunctive and cumulative scheduling. Although there are examples that help solidify the discourse, more of them, especially in the sections on logic, would make this chapter more useful to practitioners.

The chapter on relaxation, in its length and finely grained development, parallels the chapter on inference. It too covers linear inequalities, a variety of constraints, propositional logic, and disjunctive and cumulative scheduling. The inclusion of some practical problems would enhance the usefulness of this chapter as well.

The author rounds out the book with a chapter entitled "Dictionary of Constraints" that succinctly presents verbal and mathematical descriptions of constraints from both constraint programming and mathematical programming. Although the author is careful not to claim that the dictionary is comprehensive, it does present a substantial set of constraints covering the preponderance of problems that a reader might confront.

In summary, this book covers the field both broadly and with sufficient granularity to provide working software engineers and graduate students with both a firm theoretical grasp of optimization and the software techniques needed to solve real-world problems. I recommend the book without reservation.

Reviewer: Marlin Thomas Review #: CR140339 (1211-1112)

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