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to Engineering Problems Graphical and Interactive Decision Support Tool for Nonlinear Multiobjective Optimization Numerical Optimization Interactive Fuzzy Optimization Convex Optimization Parallel Problem Solving from Nature, PPSN XI An Interactive Knowledge-driven Multi-objective Optimization Framework for Achieving Faster Convergence Evolutionary Multi-Criterion Optimization An Interactive System Design and Optimization Algorithm

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Evolutionary algorithms are relatively new, but very powerful techniques used to find solutions to many real-world search and optimization problems. Many of these problems have multiple objectives, which leads to the need to obtain a set of optimal solutions, known as effective solutions. It has been found that using evolutionary algorithms is a highly effective way of finding multiple effective solutions in a single simulation run. Comprehensive coverage of this growing area of research Carefully introduces each algorithm with examples and in-depth discussion Includes many applications to real-world problems, including engineering design and

scheduling Includes discussion of advanced topics and future research Can be used as a course text or for self-study Accessible to those with limited knowledge of classical multi-objective optimization and evolutionary algorithms The integrated presentation of theory, algorithms and examples will benefit those working and researching in the areas of optimization, optimal design and evolutionary computing. This text provides an excellent introduction to the use of evolutionary algorithms in multi-objective optimization, allowing use as a graduate course text or for self-study. The main characteristics of the real-world decision-making problems facing humans today are multidimensional and have multiple objectives including eco nomic, environmental, social, and technical ones. Hence, it seems natural that the consideration of many objectives in the actual decision-making process re quires multiobjective approaches rather than single-objective. One ofthe major systems-analytic multiobjective approaches to decision-making under constraints is multiobjective optimization as a

generalization of traditional single-objective optimization. Although multiobjective optimization problems differ from single objective optimization problems only in the plurality of objective functions, it is significant to realize that multiple objectives are often noncom mensurable and conflict with each other in multiobjective optimization problems. With this ob servation, in multiobjective optimization, the notion of Pareto optimality or effi ciency has been introduced instead of the optimality concept for single-objective optimization. However, decisions with Pareto optimality or efficiency are not uniquely determined; the final decision must be selected from among the set of Pareto optimal or efficient solutions. Therefore, the question is, how does one find the preferred point as a compromise or satisficing solution with rational pro cedure? This is the starting point of multiobjective optimization. To be more specific, the aim is to determine how one derives a compromise or satisficing so lution of a decision maker (DM), which well represents the subjective judgments, from a

Pareto optimal or an efficient solution set. He consider a cone dominance problem: given a "preference" cone lP and a set n X ~ R of available, or feasible, alternatives, the problem is to identify the non dominated elements of X. The nonzero elements of lP are assumed to model the do- nance structure of the problem so that y s X dominates x s X if Y = x + P for some nonzero p S lP. Consequently, x S X is nondominated if, and only if, ({x} + lP) n X = {x} (1.1) He will also refer to nondominated points as efficient points (in X with respect to lP) and we will let EF(XJP) denote the set of such efficient points. This cone dominance problem draws its roots from two separate, but related, ori gins. The first of these is multi-attribute decision making in which the elements of the set X are endowed with various attributes, each to be maximized or minimized. Multi-criterio noptimizationreferstooptimizationproblems withtwoormore- jectives expressing con?icting goals that are formulated within a mathematical programming framework. The problems addressed may involve linear or nonl- ear objective functions and/or

constraints, continuous or discrete variables, and may or may not be a?ected by uncertainty in the data. This branch of multiple criteria decision making (MCDM) ?nds application in numerous domains: en- neering design, health, transportation,telecommunications, bioinformatics, etc. The concept of a unique optimal solution does not apply as soon as multiple objectives are optimized simultaneously. The models and methods introduced in multi-criterion optimization deal with the concept of a set of e?cient (also called Pareto optimal) solutions. E?cient solutions imply trade-o?s between the di?erentcriteria. Thecomputationofthee? cientsolutionsetmaybehardwhen the size of the problem is large, when the problem is computationally complex, when the data are not crisp. It is then often impossible to guarantee the com- tation of exact solutions. In that case, approximate solutions, i. e. , sub-optimal solutionscompu tedwithlimitedandcontrolledresources,such asavailabletime, are of interest. This is the domain of multi-objective metaheuristics, of which evolutionary multi-criterion

optimization (EMO) is de?nitely the most pro- nent representative. The success of EMO is due to the simplicity of its concepts and the generality of its methods, and is clearly expressed by the many impr- sive success stories reported in the literature. Research activities in EMO have boomed since the mid-1990s. Three g- erations of work are identi?able throughout the years. Simultaneous considerations of multiobjectiveness, fuzziness and block angular structures involved in the real-world decision making problems lead us to the new field of interactive multiobjective optimization for large scale programming problems under fuzziness. The aim of this book is to introduce the latest advances in the new field of interactive multiobjective optimization for large scale programming problems under fuzziness on the basis of the author's continuing research. Special stress is placed on interactive decision making aspects of fuzzy multiobjective optimization for human-centered systems in most realistic situations when dealing with fuzziness. The book is intended for graduate students, researchers and

practitioners in the fields of operations research, industrial engineering, management science and computer science. This text offers many multiobjective optimization methods accompanied by analytical examples, and it treats problems not only in engineering but also operations research and management. It explains how to choose the best method to solve a problem and uses three primary application examples: optimization of the numerical simulation of an industrial process; sizing of a telecommunication network; and decision-aid tools for the sorting of bids. This book constitutes the refereed proceedings of the Third International Conference on Evolutionary Multi-Criterion Optimization, EMO 2005, held in Guanajuato, Mexico, in March 2005. The 59 revised full papers presented together with 2 invited papers and the summary of a tutorial were carefully reviewed and selected from the 115 papers submitted. The papers are organized in topical sections on algorithm improvements, incorporation of preferences, performance analysis and comparison, uncertainty and noise,

alternative methods, and applications in a broad variety of fields. This book constitutes the refereed proceedings of the 9th International Conference on Evolutionary Multi-Criterion Optimization, EMO 2017 held in Münster, Germany in March 2017. The 33 revised full papers presented together with 13 poster presentations were carefully reviewed and selected from 72 submissions. The EMO 2017 aims to discuss all aspects of EMO development and deployment, including theoretical foundations; constraint handling techniques; preference handling techniques; handling of continuous, combinatorial or mixed-integer problems; local search techniques; hybrid approaches; stopping criteria; parallel EMO models; performance evaluation; test functions and benchmark problems; algorithm selection approaches; many-objective optimization; large scale optimization; real-world applications; EMO algorithm implementations. Since the volume may be of interest to a broad variety of people, it is arranged in parts that require different levels of mathematical background. Part I

can be assessed by those interested in the application of visualization methods in decision making. In Part II computational methods are introduced in a relatively simple form. Part III is written for readers in applied mathematics interested in the theoretical basis of modern optimization. Yhteenveto. Problems with multiple objectives and criteria are generally known as multiple criteria optimization or multiple criteria decision-making (MCDM) problems. So far, these types of problems have typically been modelled and solved by means of linear programming. However, many real-life phenomena are of a nonlinear nature, which is why we need tools for nonlinear programming capable of handling several conflicting or incommensurable objectives. In this case, methods of traditional single objective optimization and linear programming are not enough; we need new ways of thinking, new concepts, and new methods - nonlinear multiobjective optimization. Nonlinear Multiobjective Optimization provides an extensive, up-to-date, self-contained and consistent survey, review of the literature and of the state of

the art on nonlinear (deterministic) multiobjective optimization, its methods, its theory and its background. The amount of literature on multiobjective optimization is immense. The treatment in this book is based on approximately 1500 publications in English printed mainly after the year 1980. Problems related to real-life applications often contain irregularities and nonsmoothnesses. The treatment of nondifferentiable multiobjective optimization in the literature is rather rare. For this reason, this book contains material about the possibilities, background, theory and methods of nondifferentiable multiobjective optimization as well. This book is intended for both researchers and students in the areas of (applied) mathematics, engineering, economics, operations research and management science; it is meant for both professionals and practitioners in many different fields of application. The intention has been to provide a consistent summary that may help in selecting an appropriate method for the problem to be solved. It is hoped the extensive bibliography will be of value to

researchers. Multiobjective optimization deals with solving problems having not only one, but multiple, often conflicting, criteria. Such problems can arise in practically every field of science, engineering and business, and the need for efficient and reliable solution methods is increasing. The task is challenging due to the fact that, instead of a single optimal solution, multiobjective optimization results in a number of solutions with different trade-offs among criteria, also known as Pareto optimal or efficient solutions. Hence, a decision maker is needed to provide additional preference information and to identify the most satisfactory solution. Depending on the paradigm used, such information may be introduced before, during, or after the optimization process. Clearly, research and application in multiobjective optimization involve expertise in optimization as well as in decision support. This state-of-the-art survey originates from the International Seminar on Practical Approaches to Multiobjective Optimization, held in Dagstuhl Castle, Germany, in December 2006, which brought together leading

experts from various contemporary multiobjective optimization fields, including evolutionary multiobjective optimization (EMO), multiple criteria decision making (MCDM) and multiple criteria decision aiding (MCDA). This book gives a unique and detailed account of the current status of research and applications in the field of multiobjective optimization. It contains 16 chapters grouped in the following 5 thematic sections: Basics on Multiobjective Optimization; Recent Interactive and Preference-Based Approaches; Visualization of Solutions; Modelling, Implementation and Applications; and Quality Assessment, Learning, and Future Challenges. The main characteristics of the real-world decision-making problems facing humans today are multidimensional and have multiple objectives including eco nomic, environmental, social, and technical ones. Hence, it seems natural that the consideration of many objectives in the actual decision-making process re quires multiobjective approaches rather than single-objective. One ofthe major systems-analytic multiobjective approaches to

decision-making under constraints is multiobjective optimization as a generalization of traditional single-objective optimization. Although multiobjective optimization problems differ from single objective optimization problems only in the plurality of objective functions, it is significant to realize that multiple objectives are often noncom mensurable and conflict with each other in multiobjective optimization problems. With this ob servation, in multiobjective optimization, the notion of Pareto optimality or effi ciency has been introduced instead of the optimality concept for single-objective optimization. However, decisions with Pareto optimality or efficiency are not uniquely determined; the final decision must be selected from among the set of Pareto optimal or efficient solutions. Therefore, the question is, how does one find the preferred point as a compromise or satisficing solution with rational pro cedure? This is the starting point of multiobjective optimization. To be more specific, the aim is to determine how one derives a compromise or satisficing so

lution of a decision maker (DM), which well represents the subjective judgments, from a Pareto optimal or an efficient solution set. Many kinds of practical problems such as engineering design, industrial m- agement and ?nancial investment have multiple objectives con?icting with eachother. Those problemscanbeformulatedasmultiobjectiveo ptimization. In multiobjective optimization, there does not necessarily a unique solution which minimizes (or maximizes) all objective functions. We usually face to the situation in which if we want to improve some of objectives, we have to give up other objectives. Finally, we pay much attention on how much to improve some of objectives and instead how much to give up others. This is called “trade-o?. ” Note that making trade-o? is a problem of value ju- ment of decision makers. One of main themes of multiobjective optimization is how to incorporate value judgment of decision makers into decision s- port systems. There are two major issues in value judgment (1) multiplicity of value judgment and (2) dynamics of value judgment. The multiplicity of value

judgment is treated as trade-o? analysis in multiobjective optimi- tion. On the other hand, dynamics of value judgment is di?cult to treat. However, it is natural that decision makers change their value judgment even in decision making process, because they obtain new information during the process. Therefore, decision support systems are to be robust against the change of value judgment of decision makers. To this aim, interactive p- grammingmethodswhichsearchasolutionwhileelicitingpartialinformation on value judgment of decision makers have been developed. Those methods are required to perform ?exibly for decision makers' attitude. Convex optimization problems arise frequently in many different fields. This book provides a comprehensive introduction to the subject, and shows in detail how such problems can be solved numerically with great efficiency. The book begins with the basic elements of convex sets and functions, and then describes various classes of convex optimization problems. Duality and approximation techniques are then covered, as are statistical estimation techniques. Various

geometrical problems are then presented, and there is detailed discussion of unconstrained and constrained minimization problems, and interior-point methods. The focus of the book is on recognizing convex optimization problems and then finding the most appropriate technique for solving them. It contains many worked examples and homework exercises and will appeal to students, researchers and practitioners in fields such as engineering, computer science, mathematics, statistics, finance and economics. 1. Introduction.- 1.1 Multiple-Objective Optimization.- 1.2 Dominance And Efficiency.- 1.3 Multiattribute Value And Utility Theory.- 1.4 Functional Forms And Independence Conditions.- 1.5 Value Functions As Compared To Utility Functions.- 1.6 Optimizing The Multiattribute Utility Or Value Function.- 1.7 References.- 1.8 Other Relevant Readings.- 2. Linear Goal Programming.- 2.1 The Goal Programming Model.- 2.2 Aspiration Levels.- 2.3 Weights.- 2.4 Preemptive Priorities.- 2.5 Multiattribute Value Theory.- 2.6 Specifying The Weights In An Additive Value Function.-

2.7 Sensitivity Analysis.- 2.8 References.- 2.9 Other Relevant Readings.- 3. Generalizing Goal Programming.- 3.1 Linear Goal Programming.- 3.2 Piecewise Linear Approximations Of Single Attribute Value Functions.- 3.3 Goal Programming With A Multiplicative Value Function.- 3.4 Nonlinear Goal Programming.- 3.5 References.- 4. Compromise Programming.- 4.1 Ideal Solutions.- 4.2 Compromise Functions.- 4.3 Compromise Solutions And The Compromise Set.- 4.4 The Anti-Ideal And Compromise Programming.- 4.5 The Method Of The Displaced Ideal.- 4.6 Compromise Programming, Linear Goal Programming, And Multiattribute Value Functions.- 4.7 References.- 5. Decision Making and the Efficient Set.- 5.1 The Efficient Set.- 5.2 Intra-Set Point Generation.- 5.3 Filtering.- 5.4 Clustering.- 5.5 Matching And Grouping.- 5.6 Sectioning.- 5.7 A Stochastic Screening Approach.- 5.8 References.- 5.9 Other Relevant Readings.- 6. Interactive Methods.- 6.1 The General Interactive Approach.- 6.2 Examples Of Interactive Methods.- 6.3 Simplified Interactive

Multiple Objective Linear Programming (SIMOLP).- 6.4 Interactive Multiobjective Complex Search.- 6.5 Choosing An Interactive Method.- 6.6 References.- 7. Computational Efficiency and Problems with Special Structure.- 7.1 Network Flow Problems.- 7.2 Multiple Objective Network Flow ProbLems.- 7.3 A Network Specialization Of A Multiobjective Simplex Algorithm.- 7.4 Compromise Solutions For The Multiobjective Network Flow Problem.- 7.5 Interactive Methods For The Multiobjective Network Flow Problem.- 7.6 References.- 8. Computational Efficiency and Linear Problems of General Structure.- 8.1 Computational Efficiency And The Ideal Solution.- 8.2 Test Problems.- 8.3 Computer Codes.- 8.4 Results.- 8.5 Other Computational Studies.- 8.6 References.- 9. Using Multiobjective Linear Programming to Reconcile Preferences Over Time.- 9.1 Preferences Over Time.- 9.2 The Behavioral Properties Of NPV.- 9.3 A More General NPV Model.- 9.4 Using Multiobjective Linear Programming As An Alternative To NPV.- 9.5 The Advantages Of Using Multiobjective Linear Programming For Reconciling

Preferences Over Time.- 9.6 References.- 10. Data Presentation and Multiobjective Optimization.- 10.1 Data Representation And The Axioms Of Utility Theory.- 10.2 The Framing Of Decisions.- 10.3 Reconciling The Decision Frame.- 10.4 Perception Of The Ideal.- 10.5 References. The design of most modern engineering systems entails the consideration of a good trade-off between the several targets requirements to be satisfied along the system life such as high reliability, low redundancy and low operational costs. These aspects are often in conflict with one another, hence a compromise solution has to be sought. Innovative computing techniques, such as genetic algorithms, swarm intelligence, differential evolution, multi-objective evolutionary optimization, just to name few, are of great help in founding effective and reliable solution for many engineering problems. Each chapter of this book attempts to using an innovative computing technique to elegantly solve a different engineering problem. This book constitutes the refereed proceedings of the 11th International Conference on Parallel

Problem Solving from Nature - PPSN XI, held in Kraków, Poland, in September 2010. The 131 revised full papers were carefully reviewed and selected from 232 submissions. The conference covers a wide range of topics, from evolutionary computation to swarm intelligence, from bio-inspired computing to real world applications. Machine learning and mathematical games supported by evolutionary algorithms as well as memetic, agent-oriented systems are also represented. This volume presents up-to-date material on the state of the art in evolutionary and deterministic methods for design, optimization and control with applications to industrial and societal problems from Europe, Asia, and America. EUROGEN 2015 was the 11th of a series of International Conferences devoted to bringing together specialists from universities, research institutions and industries developing or applying evolutionary and deterministic methods in design optimization, with emphasis on solving industrial and societal problems. The conference was organised around a

number of parallel symposia, regular sessions, and keynote lectures focused on surrogate-based optimization in aerodynamic design, adjoint methods for steady & unsteady optimization, multi-disciplinary design optimization, holistic optimization in marine design, game strategies combined with evolutionary computation, optimization under uncertainty, topology optimization, optimal planning, shape optimization, and production scheduling. Optimization is an important tool used in decision science and for the analysis of physical systems used in engineering. One can trace its roots to the Calculus of Variations and the work of Euler and Lagrange. This natural and reasonable approach to mathematical programming covers numerical methods for finite-dimensional optimization problems. It begins with very simple ideas progressing through more complicated concepts, concentrating on methods for both unconstrained and constrained optimization. Graph algorithms are easy to visualize and indeed there already exists a variety of packages to animate the

dynamics when solving problems from graph theory. Still it can be difficult to understand the ideas behind the algorithm from the dynamic display alone. CATBox consists of a software system for animating graph algorithms and a course book which we developed simultaneously. The software system presents both the algorithm and the graph and puts the user always in control of the actual code that is executed. In the course book, intended for readers at advanced undergraduate or graduate level, computer exercises and examples replace the usual static pictures of algorithm dynamics. For this volume we have chosen solely algorithms for classical problems from combinatorial optimization, such as minimum spanning trees, shortest paths, maximum flows, minimum cost flows, weighted and unweighted matchings both for bipartite and non-bipartite graphs. Find more information at http://schliep.org/CATBox/. Evolutionary Multi-Objective Optimization is an expanding field of research. This book brings a collection of papers with some of the most recent advances in this field. The

topic and content is currently very fashionable and has immense potential for practical applications and includes contributions from leading researchers in the field. Assembled in a compelling and well-organised fashion, Evolutionary Computation Based Multi-Criteria Optimization will prove beneficial for both academic and industrial scientists and engineers engaged in research and development and application of evolutionary algorithm based MCO. Packed with must-find information, this book is the first to comprehensively and clearly address the issue of evolutionary computation based MCO, and is an essential read for any researcher or practitioner of the technique. Since the introduction of genetic algorithms in the 1970s, an enormous number of articles together with several significant monographs and books have been published on this methodology. As a result, genetic algorithms have made a major contribution to optimization, adaptation, and learning in a wide variety of unexpected fields. Over the years, many excellent books in genetic algorithm

optimization have been published; however, they focus mainly on single-objective discrete or other hard optimization problems under certainty. There appears to be no book that is designed to present genetic algorithms for solving not only single-objective but also fuzzy and multiobjective optimization problems in a unified way. Genetic Algorithms And Fuzzy Multiobjective Optimization introduces the latest advances in the field of genetic algorithm optimization for 0-1 programming, integer programming, nonconvex programming, and job-shop scheduling problems under multiobjectiveness and fuzziness. In addition, the book treats a wide range of actual real world applications. The theoretical material and applications place special stress on interactive decision-making aspects of fuzzy multiobjective optimization for human-centered systems in most realistic situations when dealing with fuzziness. The intended readers of this book are senior undergraduate students, graduate students, researchers, and practitioners in the fields of operations

research, computer science, industrial engineering, management science, systems engineering, and other engineering disciplines that deal with the subjects of multiobjective programming for discrete or other hard optimization problems under fuzziness. Real world research applications are used throughout the book to illustrate the presentation. These applications are drawn from complex problems. Examples include flexible scheduling in a machine center, operation planning of district heating and cooling plants, and coal purchase planning in an actual electric power plant. Multiobjective optimization deals with solving problems having not only one, but multiple, often conflicting, criteria. Such problems can arise in practically every field of science, engineering and business, and the need for efficient and reliable solution methods is increasing. The task is challenging due to the fact that, instead of a single optimal solution, multiobjective optimization results in a number of solutions with different trade-offs among criteria, also known as Pareto optimal or efficient solutions. Hence, a decision maker

is needed to provide additional preference information and to identify the most satisfactory solution. Depending on the paradigm used, such information may be introduced before, during, or after the optimization process. Clearly, research and application in multiobjective optimization involve expertise in optimization as well as in decision support. This state-of-the-art survey originates from the International Seminar on Practical Approaches to Multiobjective Optimization, held in Dagstuhl Castle, Germany, in December 2006, which brought together leading experts from various contemporary multiobjective optimization fields, including evolutionary multiobjective optimization (EMO), multiple criteria decision making (MCDM) and multiple criteria decision aiding (MCDA). This book gives a unique and detailed account of the current status of research and applications in the field of multiobjective optimization. It contains 16 chapters grouped in the following 5 thematic sections: Basics on Multiobjective Optimization; Recent Interactive and Preference-Based Approaches; Visualization

of Solutions; Modelling, Implementation and Applications; and Quality Assessment, Learning, and Future Challenges. The title of this book seems to indicate that the volume is dedicated to a very specialized and narrow area, i. e. , to the relationship between a very special type of optimization and mathematical programming. The contrary is however true. Optimization is certainly a very old and classical area which is of high concern to many disciplines. Engineering as well as management, politics as well as medicine, artificial intelligence as well as operations research, and many other fields are in one way or another concerned with optimization of designs, decisions, structures, procedures, or information processes. It is therefore not surprising that optimization has not grown in a homogeneous way in one discipline either. Traditionally, there was a distinct difference between optimization in engineering, optimization in management, and optimization as it was treated in mathematical sciences. However, for the last decades all these fields have to an increasing degree interacted and

contributed to the area of optimization or decision making. In some respects, new disciplines such as artificial intelligence, descriptive decision theory, or modern operations research have facilitated, or even made possible the interaction between the different classical disciplines because they provided bridges and links between areas which had been developing and applied quite independently before. The development of optimiiation over the last decades can best be appreciated when looking at the traditional model of optimization. For a well-structured, Le. Users interested in solving real-world optimization problems often have many years of experience. Their intuition or 'knowledge' is often overlooked in academic studies due to concerns regarding loss of generality. Such knowledge can be expressed as inter-variable relationships or functions, which can provide some initial guidance to a suitably-designed optimization algorithm. Alternatively, knowledge about variable interactions can also be extracted algorithmically during the optimization by analyzing the better

solutions progressively found over iterations - a process termed innovization. Any common pattern extracted from good solutions discovered during an optimization run can be used as a repair operator to modify candidate solutions, but the key aspect is to strike a balance between the relevance of the pattern identified and the extent of its use in the repair operator, lest the learned patterns turn out to be properties of unpromising search directions or 'blind alleys'.In this dissertation, we propose a framework combining both user-supplied and algorithmically-extracted knowledge to repair solutions during an optimization run in an online fashion. Such a framework is also interactive, allowing the user to provide inputs at any point during the optimization. We show the step-wise modifications required for an evolutionary multi-objective (EMO) framework to allow for: (a) initial user-provided knowledge, (b) automated knowledge extraction and application using innovization methods, and (c) allowing the user to interact with the framework at any point during the optimization run. The path to creating such

a framework is systematically performed one step at a time, starting from creating an efficient method of representing problem knowledge, designing a suitable automated innovization procedure, and finally interleaving human-provided and machine-extracted knowledge. We show that such a framework can achieve faster convergence across a variety of practical optimization problems. Some future research directions are also discussed. Optimization has been playing a key role in the design, planning and operation of chemical and related processes for nearly half a century. Although process optimization for multiple objectives was studied by several researchers back in the 1970s and 1980s, it has attracted active research in the last 10 years, spurred by the new and effective techniques for multi-objective optimization. In order to capture this renewed interest, this monograph presents the recent and ongoing research in multi-optimization techniques and their applications in chemical engineering. Following a brief introduction and general review on the development of multi-objective optimization

applications in chemical engineering since 2000, the book gives a description of selected multi-objective techniques and then goes on to discuss chemical engineering applications. These applications are from diverse areas within chemical engineering, and are presented in detail. All chapters will be of interest to researchers in multi-objective optimization and/or chemical engineering; they can be read individually and used in one''s learning and research. Several exercises are included at the end of many chapters, for use by both practicing engineers and students.

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