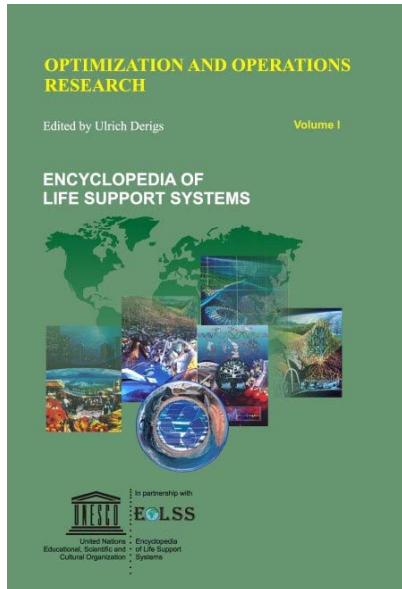


CONTENTS

OPTIMIZATION AND OPERATIONS RESEARCH



Optimization and Operations Research - Volume 1

No. of Pages: 324

ISBN: 978-1-905839-48-3 (eBook)

ISBN: 978-1-84826-948-4 (Print Volume)

Optimization and Operations Research - Volume 2

No. of Pages: 314

ISBN: 978-1-905839-49-0 (eBook)

ISBN: 978-1-84826-949-1 (Print Volume)

Optimization and Operations Research - Volume 3

No. of Pages: 405

ISBN: 978-1-905839-50-6 (eBook)

ISBN: 978-1-84826-950-7 (Print Volume)

Optimization and Operations Research - Volume 4

No. of Pages: 493

ISBN: 978-1-905839-51-3 (eBook)

ISBN: 978-1-84826-951-4 (Print Volume)

For more information of e-book and Print Volume(s) order, please [click here](#)

Or contact : eolssunesco@gmail.com

CONTENTS

VOLUME I

Optimization and Operations Research **1**
 Ulrich Derigs, *Director, Department of Information Systems and Operations Research (WINFORS),
 University of Cologne, Cologne, Germany*

1. Introduction
 - 1.1. What is “Optimization”?
 - 1.2. What is “Operations Research”?
2. Optimization and operations research: history and organizations
 - 2.1. The Roots and Origins
 - 2.2. Optimization and Operations Research Organizations
3. Optimization and operations research: impact and excellence
 - 3.1. Success Stories of OR
 - 3.2. Appearance and Recognition of Operations Research
 - 3.3. The Road Ahead
4. Operations research: scientific decision-making and the role of modeling
 - 4.1. Decision Analysis
 - 4.2. The Methodology of Operations Research
 - 4.2.1. Formulating the Problem: The Conceptual Phase
 - 4.2.2. Developing a Mathematical Model: The Design Phase
 - 4.2.3. Deriving a Solution to the Model: the Algorithmic Phase
 - 4.2.4. Testing and Validation of the Model: the Validation Phase
5. Optimization: the mathematical theory of models and algorithms
 - 5.1. Deterministic Optimization
 - 5.1.1. The Generic Optimization Problem
 - 5.1.2. Unconstrained Optimization
 - 5.1.3. Nonlinear Constrained Optimization
 - 5.1.4. Linear Programming
 - 5.1.5. Graph and Network Programming
 - 5.1.6. Combinatorial Optimization and Integer Programming
 - 5.1.7. Multi-Objective Optimization
 - 5.2. Stochastic Operations Research
 - 5.2.1. Stochastic Programming
 - 5.2.2. Stochastic Decision Processes
 - 5.3. Game Theory
6. Optimization and computers: complexity and efficiency
 - 6.1. The Algorithmic (In-)Tractability of Models
 - 6.2. An Illustrative Example
7. Operations research and information systems: the implementation issue
 - 7.1. Traditional OR/MS Based Decision Systems
 - 7.2. Interactive Optimization
 - 7.3. Decision Support Systems: The Vehicle for Implementing OR/MS
 - 7.3.1. DSS: System Architecture
 - 7.3.2. DSS: Levels of Technology
 - 7.3.3. DSS: Development Methodology
8. Operations research and decision support systems: a case study
 - 8.1. A Mathematical Programming Based DSS for the Evaluation of Air Cargo Schedules
9. Selected WWW sites related to optimization and operations research

Fundamentals of Operations Research **66**
 Ulrich Derigs, *Director, Department of Information Systems and Operations Research (WINFORS),
 University of Cologne, Cologne, Germany*

1. Introduction
2. Linear Programming
 - 2.1. Examples of LP Problems
 - 2.2. Assumptions in LP Models
 - 2.3. Canonical Forms
 - 2.4. LP Solution Procedures
 - 2.4.1. Graphical Solution
 - 2.4.2. Algebraic Solution: The Simplex Method
 - 2.5. LP Duality: Optimality Conditions and Post-Optimal Analysis
3. Discrete Optimization and Integer Programming
 - 3.1. Examples of Discrete Optimization Problems
 - 3.2. The Role of Linear Programming in Integer Linear Programming
 - 3.3. Modeling Discrete Optimization Problems
 - 3.4. Solution Concepts for ILP
 - 3.4.1. The Cutting Plane Approach
 - 3.4.2. The Branch and Bound Approach
4. Nonlinear Programming
 - 4.1. Examples of Nonlinear Programming Problems
 - 4.2. Differences between Linear and Nonlinear Programs
 - 4.3. Solution Concepts for Unconstrained Optimization
 - 4.3.1. Optimality Conditions
 - 4.3.2. Basic Iterative Search Procedures
 - 4.4. Solution Concepts for Constrained Nonlinear Optimization
 - 4.4.1. Optimality Conditions
 - 4.4.2. Basic Iterative Search Procedures
5. Implementation Aspects: Efficiency and Productivity
 - 5.1. Computational Efficiency of OR Algorithms
 - 5.2. Productivity of the Modeling Process

The Role of Modeling

111

Heiner Muller-Merbach, *Universitat Kaiserslautern, Germany*

1. Introduction: Morphology of Models
2. Modeling as a Mental Activity
 - 2.1. Internal versus External Models
 - 2.2. Interdependence of Internal and External Models
 - 2.3. Greek Roots of Modeling
 - 2.4. Intentions of Modeling
 - 2.5. Models for Theory and Practice
3. Mathematical Modeling
 - 3.1. Five Types of Modeling for Practice
 - 3.2. Mathematical Models for Decision Making
 - 3.2.1. Optimization Models
 - 3.2.2. Evaluation Models
 - 3.2.3. Auxiliary Models
 - 3.3. Mathematical Models and Databases
 - 3.4. Mathematical Models and Standard Software Support

Linear Programming

133

Karl Heinz Borgwardt, *Institute for Mathematics, University of Augsburg, Germany.*

1. Linear Programming Problems
 - 1.1. Formulation of Linear Programming Problems
 - 1.2. Examples
 - 1.3. Different Forms of Programs and Transformations
2. Primal and Dual Programs and Polyhedra

- 2.1. Duality
- 2.2. Linear Inequalities and Polyhedra
- 3. The Simplex Method
 - 3.1. The Restriction-oriented Simplex Method
 - 3.2. The Variable-oriented Simplex Method
 - 3.3. Modifications of Methods and Problems
 - 3.4. The Complexity of the Simplex Method
- 4. Polynomial Solution Methods for LPs
 - 4.1. The Ellipsoid Method
 - 4.2. Interior Point Methods
 - 4.2.1. Minimizing Potential Functions
 - 4.2.2. Following the Central Path

Nonlinear Programming

169

Klaus Schittkowski, *University of Bayreuth, Germany*
 Christian Zillober, *University of Bayreuth, Germany*

- 1. Introduction
- 2. Optimality Conditions
 - 2.1. Convexity and Constraint Qualification
 - 2.2. Karush-Kuhn-Tucker Conditions
- 3. Optimization Algorithms
 - 3.1. Quasi-Newton Methods for Unconstrained Optimization
 - 3.2. Penalty and Barrier Methods
 - 3.3. Augmented Lagrangian Methods
 - 3.4. Interior Point Methods
 - 3.5. Sequential Linear Programming
 - 3.6. Sequential Quadratic Programming
 - 3.7. Generalized Reduced Gradient Methods
 - 3.8. Sequential Convex Programming
- 4. Large Scale Optimization
 - 4.1. Limited Memory Quasi-Newton Updates
 - 4.2. Sequential Linear Programming
 - 4.3. Interior Point Methods
 - 4.4. Sequential Quadratic Programming
 - 4.5. Sequential Convex Programming

Dynamic Programming

192

Moshe Sniedovich, *The University of Melbourne, Parkville, Australia*

- 1. Introduction
- 2. Preliminary Examples
- 3. Sequential Decision Processes
- 4. Decomposition of Objective Functions
- 5. Functional Equations
- 6. Policies
- 7. Algorithms
 - 7.1. Direct Methods
 - 7.2. Successive Approximation
 - 7.2.1. Successive Approximation in the Return Space
 - 7.2.2. Successive Approximation in the Policy Space
 - 7.3. Recovery Procedures
 - 7.3.1. Store-First Approach
 - 7.3.2. On-the-Fly Approach
- 8. The Principle of Optimality
- 9. The Curse of Dimensionality

- 10. Generalizations
- 11. The Art of Dynamic Programming
 - 11.1. Models
 - 11.2. Algorithms
 - 11.3. Computer Codes (see *Graph and Network Optimization*)
- 12. Epilogue

Discrete Optimization 234
 Franz Rendl, *Institut für Mathematik, Universität Klagenfurt, Austria*

- 1. Introduction
- 2. Modeling
 - 2.1. Linear Models
 - 2.2. Models with Quadratic Functions
- 3. Solution Methods
 - 3.1. Linear Optimization
 - 3.2. Nonlinear Relaxations
 - 3.3. Heuristics
 - 3.4. Branch and Bound

The Role of Software in Optimization and Operations Research 244
 Harvey J. Greenberg, *University of Colorado at Denver, USA*

- 1. Introduction
- 2. Historical Perspectives
- 3. Obtaining a Solution
 - 3.1. Data structures, Controls and Interfaces
 - 3.2. Parallel Algorithms
- 4. Modeling
 - 4.1. Expressive Power
 - 4.2. Logic Programming and Optimization
- 5. Computer-Assisted Analysis
 - 5.1. Query and Reporting
 - 5.2. Debugging
- 6. Intelligent Mathematical Programming Systems
 - 6.1. Formulation
 - 6.2. Model and Scenario Management
 - 6.3. Discourse
 - 6.4. Analysis
- 7. Beyond the Horizon

Index 267

About EOLSS 273

VOLUME II

Advanced Deterministic Optimization 1
 Thomas M. Liebling, *Ecole Polytechnique Federale de Lausanne, France*
 Alain Prodon, *Ecole Polytechnique Federale de Lausanne, France*
 Leslie E. Jr. Trotter, *Cornell University, Ithaca, New York, USA*

- 1. Introduction

2. Foundations
 - 2.1. Algebra and Geometry of Linear Systems
 - 2.2. Fundamental Algorithms
 - 2.3. Combinatorial Optimization
 - 2.4. Linear Programming
3. Seminal Development-Discrete Optimization
 - 3.1. Spanning Trees
 - 3.2. Shortest Paths
 - 3.3. Job Scheduling
 - 3.4. Network Flows
 - 3.5. Routing
 - 3.6. Matching and Extensions
 - 3.7. Matroids
 - 3.8. Computational Complexity
 - 3.9. Linear programming Complexity
 - 3.10. Integer Programming Complexity
 - 3.11. Integral Polyhedra
 - 3.12. Packing and Covering
 - 3.13. Cutting Planes
 - 3.14. Approximation Schemes
 - 3.15. Heuristics

Combinatorial Optimization and Integer Programming

72

Michael Junger, *Institut für Informatik, Universität zu Köln, Germany*

Gerhard Reinelt, *Institut für Informatik, Universität Heidelberg, Germany*

1. Introduction
2. Modeling
 - 2.1. Example Applications
 - 2.2. Generic Models
3. Mathematical Foundations
 - 3.1. Complexity
 - 3.2. Polyhedra
 - 3.3. Linear Programming
 - 3.4. Relations between Problems
 - 3.5. Relaxations
 - 3.5.1. Combinatorial Relaxation
 - 3.5.2. Linear Programming Relaxation
 - 3.5.3. Lagrangian Relaxation
4. Algorithmic Approaches
 - 4.1. Modeling Issues
 - 4.2. Polynomial Algorithms
 - 4.3. Branch-and-Bound
 - 4.4. Cutting Plane Algorithms
 - 4.5. Column Generation
 - 4.6. Primal Methods
 - 4.7. Dynamic Programming
 - 4.8. Heuristics
5. Software

Graph and Network Optimization

92

Ravindra K. Ahuja, *University of Florida, Gainesville, Florida, USA*

James B. Orlin, *Sloan School of Management, Massachusetts Institute of Technology, Cambridge, Mass., USA*

1. Introduction

2. Preliminaries
3. Shortest Path Problem
 - 3.1. Introduction
 - 3.2. Applications
 - 3.3. Label-Correcting Algorithms
 - 3.4. A Modified Label-Correcting Algorithm
 - 3.5. Specific Implementations of the Modified Label-Correcting Algorithm
4. The Maximum Flow Problem
 - 4.1. Introduction
 - 4.2. Applications
 - 4.3. Background
 - 4.4. The Generic Augmenting Path Algorithm
5. The Minimum Cost Flow Problem
 - 5.1. Introduction
 - 5.2. Applications
 - 5.3. The Cycle-Canceling Algorithm
6. The Minimum Spanning Tree Problem
 - 6.1. Introduction
 - 6.2. Applications
 - 6.3. Optimality Conditions
 - 6.4. Kruskal's Algorithm

Scheduling**119**

Peter Brucker, *University of Osnabruck, Germany*
 Sigrid Knust, *University of Osnabruck, Germany*

1. Introduction
2. General Scheduling Models
3. Applications
 - 3.1. Project Scheduling
 - 3.2. Machine Scheduling Problems
 - 3.3. Timetabling
4. Classification, Complexity and Solution Methods
 - 4.1. A Classification Scheme
 - 4.2. Polynomially Solvable Scheduling Problems
 - 4.3. NP-hard Scheduling Problems
 - 4.4. Complexity of Single-Machine Problems
 - 4.5. Living with NP-hard Problems

Routing Problems**145**

Ulrich Derigs, *University of Cologne, Cologne, Germany*

1. Introduction
2. The Chinese Postman Problem
 - 2.1. The Undirected Postman Problem
 - 2.2. The Directed Postman Problem
 - 2.3. The Mixed Postman Problem
 - 2.4. Some Variants of the Classical Postman Problem
3. The Traveling Salesman Problem
 - 3.1. Mathematical Programming-Based Formulations and Algorithms
 - 3.1.1. The Asymmetric Case
 - 3.1.2. The Symmetric Case
 - 3.2. Heuristic Methods
 - 3.2.1. Construction Heuristics
 - 3.2.2. Improvement Heuristics
 - 3.3. Some Variants of the Classical Traveling Salesman Problem

4. Vehicle Routing Problems
 - 4.1. Mathematical Programming-Based Formulations and Algorithms
 - 4.1.1. The Generalized Assignment Approach
 - 4.1.2. The Set Partitioning Approach
 - 4.1.3. Approaches from Polyhedral Combinatorics
 - 4.2. Heuristic Methods
 - 4.2.1. Constructive Methods
 - 4.2.2. Improvement Heuristics
5. Capacitated Arc Routing Problems
 - 5.1. Mathematical Programming-Based Formulations and Algorithms
 - 5.2. Heuristic Methods

Large Scale Optimization**172**Alexander Martin, *Darmstadt University of Technology, Germany*

1. Introduction
2. LP Relaxations
 - 2.1. General Cutting Planes
 - 2.2. Cutting Planes Exploiting Structure
3. Lagrangian Relaxations
4. Decomposition Methods
 - 4.1. Dantzig-Wolfe Decomposition
 - 4.2. Benders' Decomposition
5. Reformulations
6. Final Remarks

Duality Theory**195**Jorgen Tind, *University of Copenhagen, Denmark*

1. Introduction
2. Convex Programming
3. Linear Programming
4. Integer Programming
5. General Mathematical Programming
6. Conclusion

Nonsmooth Optimization**207**Claude Lemarechal, *Inria Rhône-Alpes, Montbonnot, Saint Ismier, France*Francois Oustry, *Inria Rhône-Alpes, Montbonnot, Saint Ismier, France*Jochem Zowe, *Sieglitzhoferstrasse 53, Erlangen, Germany.*

1. Introduction
2. The general problem and its motivation
 - 2.1. The Nonsmooth Problem
 - 2.2. Lagrangian Relaxation
3. Algorithms for convex optimization
 - 3.1. The Cutting-Plane Idea
 - 3.2. Stabilization: General Principles
 - 3.3. Typical Bundle Algorithm
4. Some illustrations
 - 4.1. Traveling Salesman Problems
 - 4.2. Minimizing the Maximal Eigenvalue
 - 4.3. Design of Masonry Structures

Global Optimization and Meta-Heuristics	223
Manuel Laguna, <i>University of Colorado at Boulder, USA</i>	

1. Introduction
2. Meta-Heuristic Features
3. Brief Description of Some Meta-Heuristics
 - 3.1. Tabu Search (TS)
 - 3.1.1. Use of Memory
 - 3.1.2. Intensification and Diversification
 - 3.2. Scatter Search
 - 3.2.1. Scatter Search Template
 - 3.3. Genetic Algorithms
4. Metaphors of Nature

Approximation Algorithms	243
Pierluigi Crescenzi, <i>Università di Firenze, Italy</i>	

1. Introduction
2. Combinatorial Optimization Problems
 - 2.1. Performance Ratio
 - 2.2. Approximation Algorithms
3. Design Techniques for Approximation Algorithms
 - 3.1. Sequential and Greedy Algorithms
 - 3.2. Local search
 - 3.3. Dynamic programming
 - 3.4. Approximation Classes
4. Non-approximability results
 - 4.1. The gap technique
5. Advanced Topics
 - 5.1. Input-Dependent and Asymptotic Approximation
 - 5.2. Advanced Approximation Techniques
 - 5.2.1. The Probabilistic Method
 - 5.2.2. Mathematical Programming
 - 5.3. Advanced Non-approximability Results
 - 5.3.1. The PCP Theorem
 - 5.3.2. Approximation Preserving Reductions

Index	261
--------------	------------

About EOLSS	265
--------------------	------------

VOLUME III

Optimization in Infinite Dimensions	1
Martin Brokate, <i>Technische Universität München, Germany.</i>	

1. Introduction
2. Infinite-Dimensional Optimization Problems
3. Convex Problems and Duality
4. Necessary Optimality Conditions
5. Optimal Control Problems
6. Calculus of Variations
7. Nonsmooth Problems

8. Optimal Shape Design

The Principles of the Calculus of Variations

21

Michael Gruter, *Universität des Saarlandes, Saarbrücken, Germany.*

1. Introduction
2. Classical Theory
 - 2.1. The finite dimensional case
 - 2.2. One-Dimensional Variational Integrals
 - 2.3. Multiple Integrals
3. Direct Methods
 - 3.1. Tonelli's Program
 - 3.2. Hilbert's Problems
 - 3.3. Regularity Theory
 - 3.4. Non-Convex Problems
 - 3.5. Γ -Convergence
4. Unstable Critical Points

The Maximum Principle of Pontryagin

49

Martin Brokate, *Technische Universität München, Germany.*

1. Introduction
2. The Maximum Principle
 - 2.1. Problem of Optimal Control
 - 2.2. Statement of the Maximum Principle
 - 2.3. Other Boundary Conditions
 - 2.4. Degeneracy
 - 2.5. Additional State and Control Constraints
 - 2.6. Autonomous Problems
 - 2.7. Problems with Free Final Time
3. Structure of Optimal Controls
 - 3.1. No Explicit Control Constraints
 - 3.2. Polyhedral Control Constraints
 - 3.2.1. Optimal Bang-Bang Controls
 - 3.2.2. Optimal Singular Controls
 - 3.3. State Constraints
4. Relation to Dynamic Programming
5. Numerical Solution Based on the Maximum Principle

Dynamic Programming and Bellman's Principle

61

Piermarco Cannarsa, *Università di Roma Tor Vergata, Italy*

1. Introduction
2. Optimal Control
3. Value Function and Bellman's Principle
4. The Hamilton-Jacobi-Bellman Equation
5. Optimal Feedback Synthesis

Optimization and Control of Distributed Processes

74

Matthais Heinkenschloss, *Rice University, Houston, Texas, USA*

1. Introduction
2. Optimization Problems Governed by Distributed Processes
 - 2.1. Parameter Identification Problems

- 2.2. Optimal Control Problems
- 2.3. Shape Optimization Problems
- 3. Existence and Characterization of Solutions
 - 3.1. Existence of Solutions
 - 3.2. Optimality Conditions
- 4. Discretization of the Problem
 - 4.1. Convergence of the Discretization
 - 4.2. Discretization and Optimization
- 5. Optimization Algorithms
 - 5.1. Formulation of the Optimization Problem
 - 5.2. Direct Search Methods for the Solution of the Reduced Problem
 - 5.3. Derivative-based Methods for the Solution of the Reduced Problem
 - 5.3.1. Unconstrained Problems
 - 5.3.2. Equality Constrained Problems
 - 5.3.3. Inequality Constrained Problems
 - 5.4. Derivative-Based Methods for the Solution of the Full Problem
 - 5.5. Time-Dependent Problems
 - 5.6. Model Reduction and Model Management Techniques
 - 5.7. Optimization Methods Based on Problem Decompositions

Nonconvex Variational Problems**92**Michel Chipot, *Universität Zürich, Switzerland*

- 1. Introduction
- 2. The Direct Method of the Calculus of Variations
- 3. Relaxation theory
- 4. Vector Valued Problems
- 5. Problems with No Minimizer, Minimizing Sequences
 - 5.1. Some Model Problems
 - 5.2. Young Measures
 - 5.3. Construction of Minimizing Sequences
 - 5.4. The Vectorial Case

Game Theory**111**Joachim Rosenmüller, *University of Bielefeld, Institute of Mathematical Economics IMW, D-33615 Bielefeld, Germany*Walter Trockel, *University of Bielefeld, Institute of Mathematical Economics IMW, D-33615 Bielefeld, Germany*

- 1. Introduction
- 2. Foundations of Non-cooperative Game Theory
 - 2.1. The Normal Form
 - 2.2. The Extensive Form
 - 2.3. Strategies, Equilibria, Refinements
- 3. NTU-Games
 - 3.1. The Coalitional Function
 - 3.2. Solutions
- 4. TU-Games
 - 4.1. Classification of games
 - 4.2. Solutions
- 5. The Equivalence Principle
 - 5.1. Walrasian Equilibrium
 - 5.2. Walrasian Equilibria and Cooperative Solutions
 - 5.3. Approximate and Weak Equivalence
 - 5.4. The Nash Program
- 6. Mechanism Theory

- 6.1. Historical Background
- 6.2. Implementation of Social Choice Rules
- 6.3. The Revelation Principle
- 7. Repeated Games
 - 7.1. Evaluations
 - 7.2. Folk Theorems
 - 7.3. Repeated Games with Incomplete Information
- 8. Evolution and Learning in Games
 - 8.1. Introduction
 - 8.2. Evolutionary Stable Strategies
 - 8.3. Learning in Social Contexts
- 9. Experimental Games
 - 9.1. Introduction
 - 9.2. Repeated Prisoners' Dilemma
 - 9.3. Coordination Games
 - 9.4. Bargaining Games
 - 9.5. Optimistic Conclusion
- 10. Concluding Remarks

Foundations of Non-Cooperative Games

156

Ron Holzman, *Technion-Israel Institute of Technology, Israel*

- 1. Introduction
- 2. Chess-Like Games
 - 2.1. The Description of the Game
 - 2.2. The Determinacy of Chess-Like Games
- 3. Representations of Non-Cooperative Games
 - 3.1. An Informal Description of the Class of Games
 - 3.2. The Extensive Form
 - 3.3. The Strategic Form
- 4. Two-Person Zero-Sum Games
 - 4.1. The Concept of Value
 - 4.2. The Minimax Theorem
- 5. Non-Zero-Sum Games
 - 5.1. A Few Instructive Examples
 - 5.2. The Concept of Nash Equilibrium
 - 5.3. Existence of a Pure Strategy Equilibrium in Games with Perfect Information
 - 5.4. Existence of a Mixed Strategy Equilibrium
- 6. Games with Incomplete Information
 - 6.1. The Modeling of Incomplete Information
 - 6.2. Consistency and the Extensive Form Representation

NTU-Games

181

Hans J.M. Peters, *University of Maastricht, The Netherlands*

- 1. Introduction
- 2. Basic Model and Definitions
- 3. The Core of an NTU-Game
 - 3.1. Existence of the Core
 - 3.2. An Axiomatic Characterization of the Core
 - 3.3. A Noncooperative Game Resulting in the Core
- 4. The Bargaining Set
 - 4.1. The Classical Bargaining Set
 - 4.2. Other Bargaining Sets
- 5. Values for NTU-Games
 - 5.1. Bargaining Solutions

- 5.1.1. The Nash Bargaining Solution
- 5.1.2. Other Bargaining Solutions
- 5.2. Solutions for TU-Games
 - 5.2.1. The Shapley Value
 - 5.2.2. The τ -Value
- 5.3. General NTU-Solutions
 - 5.3.1. The Shapley Solution
 - 5.3.2. The Kalai-Samet Solutions
 - 5.3.3. The Harsanyi Solution
 - 5.3.4. The Compromise Solution
 - 5.3.5. The Hart-Mas-Colell Consistent Solution
- 5.4. Characterizations of NTU-Solutions
 - 5.4.1. The Shapley Solution
 - 5.4.2. The Harsanyi Solution
 - 5.4.3. The Egalitarian Solution
- 5.5. Discussion and Examples
- 6. Concluding Remarks

TU-Games**216**Shigeo Muto, *Tokyo Institute of Technology, Japan*

- 1. Introduction
- 2. Characteristic Function Form Games
 - 2.1. Characteristic Functions
 - 2.2. Imputations
 - 2.3. Simple Examples
- 3. Solutions
 - 3.1. The Core
 - 3.1.1. Coalitional Rationality and the Core
 - 3.1.2. Cores in the Examples
 - 3.1.3. Conditions for Nonemptiness of the Core
 - 3.1.4. Dominance Relation and the Core
 - 3.2. Stable Sets
 - 3.2.1. Definition
 - 3.2.2. Stable Sets in the Examples
 - 3.2.3. Stable Sets and the Core
 - 3.3. The Bargaining Set
 - 3.3.1. Definition
 - 3.3.2. Bargaining Sets in the Examples
 - 3.4. The Kernel
 - 3.4.1. Definition
 - 3.4.2. Kernels in the Examples
 - 3.5. The Nucleolus
 - 3.5.1. Definition
 - 3.5.2. Nucleoli in the Examples
 - 3.6. The Shapley Value
 - 3.6.1. Definition
 - 3.6.2. Properties of the Shapley Value
 - 3.6.3. Shapley Values in the Examples
 - 3.6.4. An Axiomatic Characterization
- 4. Market Games
 - 4.1. Edgeworth Market Games
 - 4.2. Market Games
 - 4.3. Competitive Equilibria
 - 4.4. Competitive Allocations and the Core
- 5. Voting Games
 - 5.1. Examples and Basic Terms

- 5.2. The Core in Voting Games
- 5.3. Stable Sets in Voting Games
- 5.4. The Shapley Value in Voting Games
- 6. Other Applications
 - 6.1. The Tennessee Valley Authority
 - 6.2. A Bankruptcy Problem

The Equivalence Principle**248**Birgit Grodal, *University of Copenhagen, Denmark*

- 1. Introduction
- 2. Notation and the Basic Model
 - 2.1. Atomless Economies
 - 2.2. Finite Economies
- 3. Walrasian Equilibrium
 - 3.1. Walrasian Allocations
 - 3.2. Strongly Fair Net Trades
- 4. Equivalencies in Atomless Economies
 - 4.1. The Core
 - 4.2. The Bargaining Set
 - 4.3. The Value
 - 4.4. Axiomatic Approach to the Equivalence Phenomenon
- 5. Approximations to Equivalence: Large Finite Economies
 - 5.1. The Core
 - 5.2. The Bargaining Set
- 6. Strategic Behavior and Walrasian Equilibria
- 7. Conclusion

Mechanism Theory**274**Matthew O. Jackson, *Stanford University, Stanford, California, 94305, USA.*

- 1. Introduction
- 2. A General Mechanism Design Setting
- 3. Dominant Strategy Mechanism Design
 - 3.1. Dominant Strategies
 - 3.2. Direct Mechanisms and the Revelation Principle
 - 3.3. The Gibbard-Satterthwaite Theorem
 - 3.4. Single-Peaked Preferences and Other Restricted Domains
 - 3.5. Groves' Schemes
 - 3.6. The Pivotal Mechanism and Vickrey Auctions
 - 3.7. The Tension between Balance and Incentive Compatibility
 - 3.8. Large Numbers and Approximate Efficiency
 - 3.9. Lack of Individual Rationality in Groves' Schemes
 - 3.10. Inefficient Decisions
- 4. Bayesian Mechanism Design
 - 4.1. A Bayesian Revelation Principle
 - 4.2. A Balanced Mechanism with Independent Types
 - 4.3. Dependent Types
 - 4.4. Individual Rationality or Voluntary Participation
 - 4.5. Large Societies
 - 4.6. Correlated Types
 - 4.7. Interdependent Valuations
- 5. Implementation

Stochastic and Repeated Games 303Francoise Forges, *Universite Paris – Dauphine, , France.*

1. Introduction
2. Supergames
 - 2.1. Standard Signals
 - 2.1.1. Finitely Repeated Games
 - 2.1.2. Infinitely Repeated Games
 - 2.1.3. Discounted Games
 - 2.1.4. Variants of the Model
 - 2.2. Imperfect Monitoring
3. Repeated Games with Incomplete Information
 - 3.1. Bayesian Games
 - 3.2. Zero-Sum Games
 - 3.2.1. Lack of Information on One Side
 - 3.2.2. Incomplete Information on Both Sides
 - 3.2.3. Symmetric Information
 - 3.3. Non-Zero-Sum Games
 - 3.3.1. Lack of Information on One Side
 - 3.3.2. Other Models
4. Stochastic Games
 - 4.1. Zero-Sum Games
 - 4.2. Non-Zero-Sum Games

Evolution and Learning in Games 323Fernando Vega-Redondo, *Universidad de Alicante (Spain) and University of Essex (United Kingdom).*

1. Introduction
2. Biological Contexts: A Static Approach
3. Biological Contexts: A Dynamic Approach
4. Social Contexts
5. Equilibrium Selection: Coordination Games
6. Equilibrium Selection: Oligopoly Games
7. Conclusion

Experimental Game Theory 341Werner Guth, *Max Planck Institute of Economics, Jena, Germany*

1. Introduction
2. One-Person Decision Making
3. Experimental Results in Strategic Games
4. Alternating Offer Bargaining
5. Characteristic Function Experiments
6. Quo Vadis Experimental Game Theory?

Index 359**About EOLSS** 367**VOLUME IV****Stochastic Operations Research** 1Ulrich Rieder, *University of Ulm, Germany*

1. Introduction
2. Markov Models
3. Markov Decision Processes
4. Stochastic Games
5. Queueing Systems
6. Inventory Models
7. Investment Models
8. Adaptive Dynamic Programming

Markov Models

26

Nicole Bauerle, *Department of Optimization and Operations Research, University of Ulm, Germany.*

1. Introduction
2. Discrete-time Markov Chains
 - 2.1. Definition and first Properties
 - 2.2. Examples
 - 2.3. Classification of States and Solidarity Properties
 - 2.4. Stationary and Limit Distributions
3. Continuous-Time Markov Chains
 - 3.1. Definition and first Properties
 - 3.2. Forward and Backward Equations
 - 3.3. Examples
 - 3.4. Stationary and Limit Distributions
4. Further Models

Markov Decision Processes

49

Ulrich Rieder, *University of Ulm, Germany*

1. Introduction
2. Problem Definition and Examples
3. Finite Horizon Decision Problems
 - 3.1. The Backward Induction Algorithm
 - 3.2. Monotonicity of Optimal Policies
4. Infinite Horizon Markov Decision Problems
 - 4.1. Total Reward Criteria
 - 4.2. Computational Methods
 - 4.2.1. Policy Improvement Algorithm
 - 4.2.2. Linear Programming
 - 4.3. Average Reward Problems
 - 4.4. Computational Methods
 - 4.4.1. Policy Improvement Algorithm
 - 4.4.2. Linear Programming
5. Continuous-time Markov Decision Processes
 - 5.1. Total Reward Decision Processes
 - 5.2. Average Reward Decision Processes
6. Further Topics

Stochastic Games

72

Ulrich Rieder, *University of Ulm, Germany*

1. Introduction
2. Basic Definitions and Notations
3. Zero-Sum Stochastic Games
 - 3.1. Discounted Stochastic Games
 - 3.2. Average Reward Stochastic Games

4. General-Sum Stochastic Games
 - 4.1. Discounted Stochastic Games
 - 4.2. Average Reward Stochastic Games
5. Further Topics

Queueing Systems**84**Nicole Bauerle, *University of Ulm, Germany*

1. Introduction
2. Design of Queueing Systems
 - 2.1. Arrivals
 - 2.2. Service Facilities
 - 2.3. Queueing Discipline
3. Performance Measures and Special Queues
 - 3.1. $M/M/1$ Queue
 - 3.2. $M/M/\infty$ Queue
 - 3.3. $M/M/m$ Queue
 - 3.4. $M/M/1/K$ Queue
 - 3.5. Erlang's Loss System
 - 3.6. $M/GI/1$ Queue
 - 3.7. $GI/M/1$ Queue
4. Little's Formula
5. Queueing Networks and Examples
 - 5.1. Jackson Networks
 - 5.2. Kelly Networks
 - 5.3. Re-entrant Lines

Inventory Models**95**Karl-Heinz Waldmann, *University of Karlsruhe, Germany*

1. Introduction
2. The Basic EOQ Model
3. The Dynamic Economic Lotsize Model
4. Periodic Review Stochastic Demand Models
 - 4.1. The Single-Period Model
 - 4.2. The Finite Horizon Model
 - 4.3. The Infinite Horizon Model
 - 4.4. Generalized (s, S) Policies
 - 4.5. Multi-Level Systems
5. Continuous Review Stochastic Demand Models
 - 5.1. Poisson Demand
 - 5.2. A Two-Level System
 - 5.3. Extensions

Investment Models**106**Ulrich Rieder, *University of Ulm, Germany*

1. Introduction
2. Mean-Variance Portfolio Selection
 - 2.1. Markowitz Model
 - 2.2. Mean-Variance Portfolio with a Riskless Asset
3. Portfolio Selection in Discrete Time
 - 3.1. Stochastic Dynamic Programming Approach
 - 3.2. HARA-Utilities
4. Portfolio Selection in Continuous Time

- 4.1. Stochastic Control Approach
- 4.2. Martingale Method
- 5. Further Models

Adaptive Dynamic Programming**119**Gerhard Hubner, *University of Hamburg, Germany*

- 1. Introduction
- 2. Basic Models and Valuations
 - 2.1. Stationary Adaptive Markov Decision Models
 - 2.2. Policies and Value Functions
 - 2.3. The Average Reward Problem
 - 2.4. The Discounted Problem
- 3. Adaptive Algorithms
 - 3.1. The Principle of Estimation and Control (PEC)
 - 3.2. Nonstationary Successive Approximation and Policy Iteration
- 4. Estimation Procedures
 - 4.1. Relative Frequencies
 - 4.2. Minimum Contrast Estimation
 - 4.3. Bayesian Models and Methods
- 5. Remarks on Applications
- 6. Remarks on Related Concepts

Decision Analysis**138**Hans Wolfgang Brachinger, *University of Fribourg, Switzerland*Paul-Andre Monney, *University of Fribourg, Switzerland*

- 1. Introduction
- 2. Examples
 - 2.1. Example 1: Decision Problem Under Uncertainty
 - 2.2. Example 2: Multiple Criteria Decision Problem
- 3. General Concepts
 - 3.1. Decision Matrix
 - 3.2. Generation of Alternatives and States of Nature
 - 3.3. Dominance and Efficiency
 - 3.4. Valuation Function
- 4. Decision Making Under Uncertainty
 - 4.1. Uncertainty, Risk, and Partial Probability Information
 - 4.2. Decision Rules Under Uncertainty
 - 4.3. Decision Rules Under Risk
 - 4.4. Decision Rules Under Partial Probability Information
- 5. The Expected Utility Paradigm
 - 5.1. The St. Petersburg Paradox
 - 5.2. Certainty Equivalent
 - 5.3. Utility Function
 - 5.4. Expected Utility Principle
 - 5.5. Expected Utility Theory
 - 5.6. Rationality Axioms
 - 5.7. Empirical Results
 - 5.8. Extensions of Expected Utility
- 6. The Risk-Value Approach
 - 6.1. General Characterization
 - 6.2. Risk-Value Dominance
 - 6.3. Compensatory and Lexicographic Approaches
 - 6.4. Alternative Risk-Value Models
- 7. Graphical Representation of Decision Problems

- 7.1. Decision Trees
- 7.2. Influence Diagrams

Expected Utility Theory and Alternative Approaches**192**Ulrich Schmidt, *Christian-Albrechts- Universitaet zu Kiel, Germany*

- 1. Introduction
- 2. The General Framework
- 3. Expected Utility Theory
 - 3.1. The Theoretical Basis of Expected Utility
 - 3.2. The Empirical Performance of Expected Utility
- 4. Non-Expected Utility Theory
 - 4.1. Utility Theories with the Betweenness Property
 - 4.1.1. Characterizing Betweenness
 - 4.1.2. Weighted Utility Theory
 - 4.1.3. Implicit Weighted Utility and Implicit Expected Utility
 - 4.1.4. The Theory of Disappointment Aversion
 - 4.1.5. Empirical Performance of Betweenness
 - 4.2. Rank-Dependent Utility Theory
 - 4.2.1. Distortion of Probabilities
 - 4.2.2. Anticipated Utility
 - 4.2.3. Dual Expected Utility
 - 4.2.4. The General Rank-Dependent Model
 - 4.2.5. Cumulative Prospect Theory
 - 4.2.6. Empirical Performance of Rank-Dependent Utility

Risk-Defusing Behavior**220**Oswald Huber, *University of Fribourg, Switzerland*

- 1. Introduction
- 2. Decision Behavior: Are Lottery Tasks and Quasi-Realistic Tasks Comparable?
- 3. An Outline of the Decision Process in Quasi-Realistic Risky Decision Tasks
- 4. Risk-Defusing Behavior
 - 4.1. RDO Targets
 - 4.2. Event-Dependence of RDOs
 - 4.3. Detectability of a Negative Event
 - 4.4. Empirical Results
- 5. The Role of Probability
 - 5.1. Probabilities of Negative Outcomes
 - 5.2. Probability in Risk Defusing
- 6. Consequences for Decision Analysis
 - 6.1. Structuring the Decision Situation
 - 6.2. Cost of an RDO
 - 6.3. Potential Cognitive Biases
 - 6.3.1. Biases in Probability Judgments
 - 6.3.2. Biased Evaluation of a Favored Alternative
 - 6.3.3. Biases from Control Beliefs
- 7. Conclusion

Decision Problems and Decision Models**236**Jayavel Sounderpandian, *Department of Business, University of Wisconsin – Parkside, USA*

- 1. Introduction
- 2. A Classification of Decision Problems
 - 2.1. The Number of Decision Makers

- 2.2. The Number and Nature of the Criteria
- 2.3. The Temporal Aspects of Decisions
- 2.4. The Nature of Uncertainty
- 2.5. The Nature of the Decision Environment
- 3. Theories and Models
 - 3.1. Structuring the Problem
 - 3.2. The Expected Utility Theory
 - 3.3. The Rank-Dependent Expected Utility Theory
 - 3.4. Voting Theory
- 4. Decision Trees and Influence Diagrams
 - 4.1. Decision Trees
 - 4.2. Influence Diagrams
- 5. Concluding Remarks

Multiple-Criteria Decision Making

257

Walter Habenicht, *University of Hohenheim, Stuttgart, Germany*

Beate Scheubrein, *University of Hohenheim, Stuttgart, Germany*

Ralph Scheubrein, *University of Hohenheim, Stuttgart, Germany*

- 1. Introduction
 - 1.1. General Concepts
 - 1.1.1. Decision Space, Decision Variables, and Alternatives
 - 1.1.2. Criteria and Outcomes
 - 1.1.3. Preferences
 - 1.1.4. Decisions
 - 1.2. Dominance and Efficiency
 - 1.3. Basic Approaches
- 2. Value Function Approach
 - 2.1. Compensatory Models
 - 2.1.1. Partial Value Functions
 - 2.1.1. The Aggregating Function v^*
 - 2.2. Non-Compensatory Models
- 3. Vector Optimization
 - 3.1. Basic Concepts
 - 3.2. The Interactive Concept of Vector Optimization
 - 3.2.1. Weighting Approach
 - 3.2.2. Reference Point Approach
 - 3.3. Interactive Procedures
 - 3.3.1. The Zions and Wallenius Method
 - 3.3.2. The Step Method
 - 3.3.3. The Visual Interactive Goal-Programming Method
- 4. Final Remarks

Decision Trees and Influence Diagrams

280

Prakash P. Shenoy, *University of Kansas, Lawrence, USA*

- 1. Introduction
- 2. A Medical Diagnosis Problem
- 3. Decision Trees
 - 3.1. Decision Tree Representation
 - 3.2. Decision Tree Solution
 - 3.3. Strengths and Weaknesses of the Decision Tree Representation Technique
 - 3.4. Strengths and Weaknesses of the Decision Tree Solution Technique
- 4. Influence Diagrams
 - 4.1. Influence Diagram Representation
 - 4.2. The Arc-Reversal Technique for Solving Influence Diagrams

- 4.3. Strengths and Weaknesses of the Influence Diagram Representation Technique
- 4.4. Strengths and Weaknesses of the Arc-Reversal Solution Technique
5. Summary and Conclusions

Framing Effects in Theory and in Practice**299**Anton Kuhberger, *University of Salzburg, Austria*

1. Introduction
2. Framing Effects in Theory
 - 2.1. Prospect Theory
 - 2.2. Incomplete Information
3. Framing Effects in Practice
 - 3.1. Behavioral Economics
 - 3.2. Bargaining
 - 3.3. Insurance
 - 3.4. Tax Payment
 - 3.5. Risk–Return
 - 3.6. Labor, Finance, and Economics
 - 3.7. Health Behavior
 - 3.8. Understanding Real Decisions in Hindsight
 - 3.9. Framing in Politics
4. Moderators of Framing Effects
 - 4.1. Types of Valence Framing
 - 4.2. Regulatory Focus
5. Conclusion

Fuzzy Decision Theory**313**Heinrich J. Rommelfanger, *Institute of Statistics and Mathematics, Goethe-University Frankfurt am Main, Germany*

1. Classical Decision Model
2. Basic Definitions of the Fuzzy Set Theory
3. Modeling Fuzzy Values
4. Fuzzy Expected Values
5. Fuzzy Preference Orderings
6. The Use of Additional Information
7. Fuzzy Probabilities
8. Conclusions

Measurement of Risk**337**Hans Wolfgang Brachinger, *University of Fribourg, Switzerland*

1. Introduction
2. Standardized Risk Measures
3. Luce's Measures of Risk
4. Sarin's Measures of Risk
5. Fishburn's Measures of Pure Risk
6. Fishburn's Measures of Speculative Risk
7. Risk Measurement Under Partial Probability Information
8. Final Remarks

Foundations of Target-Based Decision Theory**361**Robert F. Bordley, *Renaissance Center, Detroit, Michigan, USA*

1. Bentham and Utility-Based Decision Analysis
2. Hobbes and Decision Analysis
3. Target-Based Decision Analysis
4. Bounded Rationality and Target-Based Decision Analysis
5. Pedagogical Advantages
6. Improved Modeling of Individual Choice
7. Better Linkages with Finance
8. State-Dependent Utility Functions
9. Better Linkages with Practice
10. More Consistent with Psychological Evidence
 - 10.1. Cognitive Psychology
 - 10.2. Depth Psychology
11. Conclusions

Index **381**

About EOLSS **389**