# CONTENTS

List of Figures ................................................. iii
Preface .................................................. iv
Acknowledgments ......................................... v
Introduction .............................................. vii

## PART I: FOUNDATIONS OF OPTIMIZATION AND ALGORITHMS

1. A Brief History of Optimization .................................. 3
   1.1 Before 1990 ........................................... 4
   1.2 Twentieth Century .................................... 6
   1.3 Heuristics and Metaheuristics .......................... 7
       Heuristics ........................................... 10

2. Challenges in Optimization ........................................ 15
   2.1 Optimization ........................................ 16
   2.2 Types of Optimization ................................ 17
   2.3 Optimization Algorithms ............................. 19
   2.4 Metaheuristics ...................................... 20
   2.5 Order Metastate ................................... 22
3.1 Upper and Lower Bounds
3.2 Basic Calculus
3.3 Optimality
   3.3.1 Continuity and Smoothness
   3.3.2 Stationary Points
   3.3.3 Optimality Criteria
3.4 Vector and Matrix Norms
3.5 Hyperplanes and Definitions
   3.5.1 Hyperplanes
   3.5.2 Definitions
3.6 Linear and Affine Functions
   3.6.1 Linear Functions
   3.6.2 Affine Functions
   3.6.3 Quadratic Forms
3.7 Convexity and Convex Functions
   3.7.1 Convexity
   3.7.2 Maximization
   3.7.3 Convex Approximation
   3.7.4 Optimality of Convex Minima
3.8 Convexity
   3.8.1 Convex Set
   3.8.2 Convex Functions
5.1 Classical Optimization Methods II
   5.1.1 Unconstrained Optimization
   5.2 Classical-Newton Methods
   5.2.1 Newton’s Method
   5.2.2 Steepest Descent Method
   5.2.3 Line Search
   5.2.4 Conjugate-Newton Methods
5.3 Constrained Optimization
5.4 Linear Programming
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>Simplex Method</td>
<td>70</td>
</tr>
<tr>
<td>4.5.2</td>
<td>Iterative Procedure</td>
<td>70</td>
</tr>
<tr>
<td>4.5.3</td>
<td>Axiom Method</td>
<td>72</td>
</tr>
<tr>
<td>4.6</td>
<td>Interior-Point Optimization</td>
<td>76</td>
</tr>
<tr>
<td>4.7</td>
<td>Penalty Method</td>
<td>76</td>
</tr>
<tr>
<td>4.8</td>
<td>Augmented Lagrange Method</td>
<td>76</td>
</tr>
<tr>
<td>4.9</td>
<td>Minimum-Maximum Method</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Moxorades</td>
<td>83</td>
</tr>
<tr>
<td>5.1</td>
<td>Direct Optimization Methods</td>
<td>88</td>
</tr>
<tr>
<td>5.2</td>
<td>Interior-Point Optimization</td>
<td>88</td>
</tr>
<tr>
<td>5.2.1</td>
<td>A. Simplex</td>
<td>88</td>
</tr>
<tr>
<td>5.2.2</td>
<td>Simplex - Generalised Simplex</td>
<td>88</td>
</tr>
<tr>
<td>5.3</td>
<td>Interior-Point Method</td>
<td>88</td>
</tr>
<tr>
<td>5.4</td>
<td>Sequential Quadratic Programming</td>
<td>91</td>
</tr>
<tr>
<td>5.4.1</td>
<td>Quadratic Programming</td>
<td>91</td>
</tr>
<tr>
<td>5.4.2</td>
<td>Sequential Quadratic Programming</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>93</td>
</tr>
<tr>
<td>6.1</td>
<td>Nonlinear Optimization</td>
<td>96</td>
</tr>
<tr>
<td>6.2</td>
<td>Convex Optimization Methods</td>
<td>96</td>
</tr>
<tr>
<td>6.2.2</td>
<td>Nonlinear Optimization Methods</td>
<td>96</td>
</tr>
<tr>
<td>6.3</td>
<td>Convex Optimization Methods</td>
<td>96</td>
</tr>
<tr>
<td>6.4</td>
<td>Nonlinear Programming</td>
<td>96</td>
</tr>
<tr>
<td>6.5</td>
<td>Mathematical Programming</td>
<td>101</td>
</tr>
<tr>
<td>6.6</td>
<td>Nonlinear Programming</td>
<td>101</td>
</tr>
<tr>
<td>7.1</td>
<td>Linear Programming Method</td>
<td>101</td>
</tr>
<tr>
<td>7.1.1</td>
<td>Convex Methods</td>
<td>101</td>
</tr>
<tr>
<td>7.1.2</td>
<td>Linear Programming Methods</td>
<td>114</td>
</tr>
<tr>
<td>7.2</td>
<td>Variational Methods with Constraints</td>
<td>120</td>
</tr>
<tr>
<td>7.3</td>
<td>Variational Methods for Multiple Variables</td>
<td>124</td>
</tr>
<tr>
<td>7.4</td>
<td>Nonconvex Convex</td>
<td>126</td>
</tr>
<tr>
<td>7.4.1</td>
<td>Convex Problems</td>
<td>126</td>
</tr>
<tr>
<td>7.4.2</td>
<td>Nonconvex Programming Principles</td>
<td>127</td>
</tr>
</tbody>
</table>
## Chapter 8

### Random Number Generators

#### 8.1 Linear Congruential Algorithms

#### 8.2 Uniform Distribution

#### 8.3 Other Distributions

#### 8.4 Metropolis Algorithms

### Chapter 9

### Chapter 10

### Chapter 11

### Chapter 12

### Part III

### Part IV

### Part V

### Part VI
16.2 Harmony Search

16.3 Implementation

References

17 Fitness Algorithms

17.1 Real-world Fitnesses

17.2 Fitness-inspired Algorithm

17.2.1 Fitness Algorithms

17.2.2 Genetic Inheritance and Adaptation

17.2.3 Scaling and Global Optimality

17.2.4 Other Special Cases

17.3 Implementation

17.3.1 Multiple Global Optimality

17.3.2 Multimodal Functions

17.3.3 TSP Variations

References

18 Multiobjective Optimization

18.1 Pareto Optimality

18.2 Weighted Sum Method

18.3 Utility Method

18.4 Multiobjective Search

18.5 Other Algorithms

References

19 Engineering Applications

19.1 Objective Design

19.2 Preference Models

19.3 Shape Optimization

19.4 Optimization of Hydrodynamic and Aerodynamic

19.5 Inverse Kinematic Element Analysis

References

Appendices

Appendix A: Test Problems for Optimization

264
Appendices 12: Mandala© Diagrams

12.1. Geometric Algorithm
12.2. Mandala Algorithm
12.3. Psychiatric Diagnostics
12.4. Therapy Group
12.5. Mobility Algorithm
12.6. Cognitive-Behavioral Therapy
12.7. Behavioral Optimization

Appendices 13: Glossary

Appendices 14: Problem Solutions

References

Index