

Contents

1	Introduction to Optimization.	1
1.1	What is Optimization?	1
1.1.1	General Problem Statement	2
1.1.2	Active/Inactive/Violated Constraints	3
1.1.3	Global and Local Minimum Points.	3
1.2	Contemporary Optimization Approaches	4
1.3	Complex Systems and Significance of Distributed Optimization	5
1.3.1	Advantages of the Distributed, Decentralized and Cooperative Approach	7
1.4	Prominent Applications of the Distributed, Decentralized and Cooperative Approach	8
	References	12
2	Probability Collectives: A Distributed Optimization Approach	15
2.1	Background of PC	15
2.2	Conceptual Framework of PC	17
2.2.1	Formulation of Unconstrained PC	18
2.2.2	Nash Equilibrium in PC	27
2.3	Characteristics of PC	28
2.4	Modified PC Approach Versus Original PC Approach	29
2.5	Validation of the Unconstrained PC	30
	References	34
3	Constrained Probability Collectives: A Heuristic Approach	37
3.1	The Traveling Salesman Problem (TSP)	37
3.1.1	The Multiple Traveling Salesmen Problem (MTSP)	38
3.1.2	The Vehicle Routing Problem (VRP)	39
3.1.3	Algorithms and Local Improvement Techniques for Solving the MTSP	41

3.2	Solution to the Multiple Depot MTSP (MDMTSP) Using PC . . .	46
3.2.1	Sampling	47
3.2.2	Formation of Intermediate Combined Route Set.	47
3.2.3	Node Insertion and Elimination Heuristic	49
3.2.4	Neighboring Approach for Updating the Sample Space. . .	51
3.2.5	Node Swapping Heuristic	51
3.3	Test Cases of the Multiple Depot MTSP (MDMTSP)	53
3.4	Test Cases of the Single Depot MTSP (SDMTSP) with Randomly Located Nodes	55
3.5	Comparison and Discussion.	56
	References	58
4	Constrained Probability Collectives with a Penalty	
	Function Approach.	61
4.1	Penalty Function Approach	61
4.2	Solutions to Constrained Test Problems	64
4.2.1	Test Problem 1	65
4.2.2	Test Problem 2	66
4.2.3	Test Problem 3	67
4.3	Discussion.	70
	References	71
5	Constrained Probability Collectives with Feasibility	
	Based Rule I	73
5.1	Feasibility-Based Rule I	74
5.1.1	Modifications to Step 5 of the Unconstrained PC Approach.	74
5.1.2	Modifications to Step 7 of the Unconstrained PC Approach.	76
5.1.3	Modifications to Step 6 of the Unconstrained PC Approach.	77
5.2	The Circle Packing Problem (CPP).	78
5.2.1	Formulation of the CPP	78
5.2.2	Case 1: CPP with Circles Randomly Initialized Inside the Square	81
5.2.3	Case 2: CPP with Circles Randomly Initialized	82
5.2.4	Voting Heuristic	83
5.2.5	Agent Failure Case.	85
5.3	Discussion.	90
	References	90

6 Probability Collectives for Discrete and Mixed Variable Problems	95
6.1 Discussion and Conclusions.	118
References	124
7 Probability Collectives with Feasibility-Based Rule II	127
7.1 Feasibility Based Rule II.	128
7.1.1 Modifications to Step 5 of the Unconstrained PC Approach.	128
7.1.2 Modifications to Step 7 of the Unconstrained PC Approach.	130
7.1.3 Modifications to Step 6 of the Unconstrained PC Approach.	130
7.2 The Sensor Network Coverage Problem (SNCP)	131
7.2.1 Formulation of the SNCP	132
7.2.2 Variations of the SNCP Solved	136
7.3 Discussion.	140
References	142
Appendix A: Analogy of Homotopy Function to Helmholtz Free Energy and Deterministic Annealing.	145
Appendix B: Nearest Newton Descent Scheme.	147
Appendix C: Broyden-Fletcher-Goldfarb-Shanno (BFGS) Method for Minimizing the Homotopy Function	149
Appendix D: Individual Sensor Coverage Calculation	153

Probability Collectives

A Distributed Multi-agent System Approach for
Optimization

Kulkarni, A.J.; Tai, K.; Abraham, A.

2015, IX, 157 p. 68 illus., Hardcover

ISBN: 978-3-319-15999-7