
Contents

Part I Introduction

1	Introduction to Cellular Genetic Algorithms	3
1.1	Optimization and Advanced Algorithms	4
1.2	Solving Problems Using Metaheuristics	6
1.3	Evolutionary Algorithms	7
1.4	Decentralized Evolutionary Algorithms	11
1.5	Cellular Evolutionary Algorithms	13
1.5.1	Synchronous and Asynchronous cEAs	16
1.5.2	Formal Characterization of the Population in cEAs	17
1.6	Cellular Genetic Algorithms	18
1.7	Conclusions	20
2	The State of the Art in Cellular Evolutionary Algorithms	21
2.1	Cellular EAs: a New Algorithmic Model	21
2.2	The Research in the Theory of the Cellular Models	22
2.2.1	Characterizing the Behavior of cEAs	24
2.2.2	The Influence of the Ratio	26
2.3	Empirical Studies on the Behavior of cEAs	26
2.4	Algorithmic Improvements to the Canonical Model	29
2.5	Parallel Models of cEAs	31
2.6	Conclusions	34

Part II Characterizing Cellular Genetic Algorithms

3	On the Effects of Structuring the Population	37
3.1	Non-decentralized GAs	37
3.1.1	Steady State GA	38
3.1.2	Generational GA	38
3.2	Decentralized GAs	39

3.3	Experimental Comparison	40
3.3.1	Cellular versus Panmictic GAs	41
3.3.2	Cellular versus Distributed GAs	43
3.4	Conclusions	46
4	Some Theory: A Selection Pressure Study on cGAs	47
4.1	The Selection Pressure	48
4.2	Theoretical Study	50
4.2.1	Approach to the Deterministic Model	50
4.2.2	A Probabilistic Model for Approaching the Selection Pressure Curve	52
4.2.3	Comparison of the Main Existing Mathematical Models	57
4.3	Validation of the Theoretical Models	60
4.3.1	Validation on Combinatorial Optimization	61
4.3.2	Validation on Continuous Optimization	65
4.4	Conclusions	68

Part III Algorithmic Models and Extensions

5	Algorithmic and Experimental Design	73
5.1	Proposal of New Efficient Models	73
5.2	Evaluation of the Results	76
5.2.1	The Mono-objective Case	77
5.2.2	The Multi-objective Case	78
5.2.3	Some Additional Definitions	80
5.3	Conclusions	82
6	Design of Self-adaptive cGAs	83
6.1	Introduction	83
6.2	Description of Algorithms	84
6.2.1	Static and Pre-Programmed Algorithms	86
6.2.2	Self-Adaptive Algorithms	87
6.3	Experimentation	90
6.3.1	Parameterization	91
6.3.2	Experimental Results	92
6.3.3	Additional Discussion	95
6.4	Conclusions	99
7	Design of Cellular Memetic Algorithms	101
7.1	Cellular Memetic Algorithms	102
7.2	Simple and Advanced Components in Cellular MAs	103
7.2.1	Three Basic Local Search Techniques for SAT	103
7.2.2	Cellular Memetic GAs	106
7.3	Computational Analysis	107

7.3.1	Effects of Combining a Structured Population and an Adaptive Fitness Function (SAW)	107
7.3.2	Results: Non Memetic Procedures for SAT	109
7.3.3	Results: Cellular Memetic Algorithms	110
7.3.4	Comparison Versus Other Algorithms in the Literature	113
7.4	Conclusions	114
8	Design of Parallel Cellular Genetic Algorithms	115
8.1	The Meta-cellular Genetic Algorithm	116
8.1.1	Parameterization	117
8.1.2	Analysis of Results	117
8.2	The Distributed Cellular Genetic Algorithm	119
8.2.1	Parameterization	120
8.2.2	Analysis of Results	123
8.3	Conclusions	125
9	Designing Cellular Genetic Algorithms for Multi-objective Optimization	127
9.1	Background on Multi-objective Optimization	129
9.2	The MOCeLL Algorithm	130
9.2.1	Extensions to MOCeLL	132
9.3	Experimental Analysis	133
9.4	Conclusions	138
10	Other Cellular Models	139
10.1	Hierarchical cGAs	139
10.1.1	Hierarchy	140
10.1.2	Dissimilarity Selection	141
10.1.3	First Theoretical Results: Takeover Times	142
10.1.4	Computational Experiments	143
10.2	Cellular Estimation of Distribution Algorithms	146
10.2.1	First Theoretical Results: Takeover Times	149
10.2.2	Computational Experiments	149
10.3	Conclusions	152
11	Software for cGAs: The JCell Framework	153
11.1	The JCell Framework	153
11.2	Using JCell	158
11.3	Conclusions	163

Part IV Applications of cGAs

12	Continuous Optimization	167
12.1	Introduction	167
12.2	Experimentation	168
12.2.1	Tuning the Algorithm	169
12.2.2	Comparison with Other Algorithms	171
12.3	Conclusions	174
13	Logistics: The Vehicle Routing Problem	175
13.1	The Vehicle Routing Problem	177
13.2	Proposed Algorithms	178
13.2.1	Problem Representation	179
13.2.2	Recombination	180
13.2.3	Mutation	181
13.2.4	Local Search	182
13.3	Solving CVRP with JCell2oli	184
13.4	New Solutions to CVRP	185
13.5	Conclusions	186
14	Telecommunications: Optimization of the Broadcasting Process in MANETs	187
14.1	The Problem	188
14.1.1	Metropolitan Mobile Ad Hoc Networks. The Madhoc Simulator	188
14.1.2	Delayed Flooding with Cumulative Neighborhood	191
14.1.3	MOPs Definition	192
14.2	A Multi-objective cGA: cMOGA	193
14.2.1	Dealing with Constraints	194
14.3	Experiments	194
14.3.1	Parameterization of cMOGA	195
14.3.2	Madhoc Configuration	196
14.3.3	Results for DFCNT	198
14.4	Comparing cMOGA Against NSGA-II	200
14.4.1	Parameterization of NSGA-II	200
14.4.2	Discussion	201
14.5	Conclusions	202
15	Bioinformatics: The DNA Fragment Assembly Problem ..	203
15.1	The DNA Fragment Assembly Problem	204
15.2	A cMA for DNA Fragment Assembly Problem	206
15.3	Results	208
15.4	Conclusions	210

Part V Appendix

A Definition of the Benchmark Problems..... 213

 A.1 Combinatorial Optimization Problems 213

 A.1.1 COUNTSAT Problem..... 213

 A.1.2 Error Correcting Codes Design Problem – ECC 214

 A.1.3 Frequency Modulation Sounds – FMS..... 215

 A.1.4 IsoPeak Problem 215

 A.1.5 Maximum Cut of a Graph – MAXCUT 216

 A.1.6 Massively Multimodal Deceptive Problem – MMDP ... 216

 A.1.7 Minimum Tardy Task Problem – MTTP 217

 A.1.8 OneMax Problem 218

 A.1.9 Plateau Problem 218

 A.1.10 P-PEAKS Problem 218

 A.1.11 Satisfiability Problem – SAT 219

 A.2 Continuous Optimization Problems 220

 A.2.1 Academic Problems..... 220

 A.2.2 Real World Problems 222

 A.3 Multi-objective Optimization Problems..... 223

References 225

Index 243