

Evolutionary Computation for Modeling and Optimization

Daniel Ashlock

January 12, 2004

Contents

1	An Overview of Evolutionary Computation	9
1.1	A Little Biology	10
	Problems	14
1.2	Evolutionary Computation	16
	Problems	21
1.3	Genetic Programming	23
	Problems	27
2	Designing Simple Evolutionary Algorithms	31
2.1	Models of Evolution	32
	Problems	36
2.2	Types of Crossover	39
	Problems	42
2.3	Mutation	43
	Problems	47
2.4	Population Size	48
	Problems	48
2.5	A Nontrivial String Evolver	49
	Problems	49
2.6	A Polymodal String Evolver	50
	Problems	55
2.7	The Many Lives of Roulette Selection	57
	Problems	61
3	Optimizing Real-Valued Functions	65
3.1	The Basic Real Function Optimizer	66
	Problems	72
3.2	Fitness Landscapes	73
	Problems	77
3.3	Niche Specialization	78

	Problems	82
3.4	Path Length, an Extended Example	84
	Problems	87
3.5	Optimizing a Discrete-Valued Function: Crossing Numbers	87
	Problems	91
4	Sunburn: Coevolving Strings	95
4.1	Definition of the Sunburn Model	95
	Problems	98
4.2	Implementing Sunburn	100
	Problems	103
4.3	Discussion and Generalizations	104
	Problems	108
4.4	Other Ways of Getting Burned	109
	Problems	112
5	Small Neural Nets : Symbots	113
5.1	Basic Symbot Description	113
	Problems	123
5.2	Symbot Bodies and Worlds	125
	Problems	128
5.3	Symbots with Neurons	128
	Problems	132
5.4	Pack Symbots	133
	Problems	134
6	Evolving Finite State Automata	137
6.1	Finite State Predictors	138
	Problems	144
6.2	The Prisoner's Dilemma I	146
	Problems	154
6.3	Other Games	155
	Problems	158
7	Ordered Structures	161
7.1	Evolving Permutations	166
	Problems	171
7.2	The Traveling Salesman Problem	173
	Problems	181
7.3	Packing Things	183

	Problems	189
7.4	Costas Arrays	191
	Problems	197
8	Plus One Recall Store	201
8.1	Overview of Genetic Programming	201
	Problems	205
8.2	The PORS Language	207
	Problems	214
8.3	Seeding Populations	215
	Problems	218
8.4	Applying Advanced Techniques to PORS	219
	Problems	222
9	Fitting to Data	225
9.1	Classical Least Squares Fit	225
	Problems	229
9.2	Simple Evolutionary Fit	231
	Problems	237
9.3	Symbolic Regression	240
	Problems	244
9.4	Automatically Defined Functions	246
	Problems	248
9.5	Working in Several Dimensions	249
	Problems	251
9.6	Introns and Bloat	253
	Problems	254
10	Tartarus: Discrete Robotics	257
10.1	The Tartarus Environment	257
	Problems	263
10.2	Tartarus with Genetic Programming	265
	Problems	270
10.3	Adding Memory to the GP-language	271
	Problems	273
10.4	Tartarus with GP-Automata	275
	Genetic Operations on GP-automata	277
	Problems	281
10.5	Allocation of Fitness Trials	282
	Problems	284

11 Evolving Logic Gates	285
11.1 Introduction to Artificial Neural Nets	285
Problems	288
11.2 Evolving Logic Gates	289
Problems	295
11.3 Selecting the Net Topology	296
Problems	301
11.4 GP-Logics	303
Problems	306
12 ISAc List: Alternative Genetic Programming	309
12.1 ISAc Lists: Basic Definitions	309
Done?	311
Generating ISAc Lists, Variation Operators	312
Data Vectors and External Objects	312
Problems	313
12.2 Tartarus Revisited	315
Problems	317
12.3 More Virtual Robotics	320
Problems	327
12.4 Return of the String Evolver	330
Problems	334
13 Graph-based Evolutionary Algorithms	337
13.1 Basic Definitions and Tools	338
Problems	343
13.2 Simple Representations	346
Problems	349
13.3 More Complex Representations	352
Problems	357
13.4 Genetic Programming on Graphs	359
Problems	364
14 Cellular Encoding	367
14.1 Shape Evolution	368
Problems	373
14.2 Cellular Encoding of Finite State Automata	376
Problems	383
14.3 Cellular Encoding of Graphs	386
Problems	398

14.4 Context Free Grammar Genetic Programming	401
Problems	409
15 Application to Bioinformatics	413
15.1 Alignment of Transposon Sequences	413
Problems	421
15.2 PCR Primer Design	422
Problems	427
15.3 DNA Bar Codes	428
Problems	440
15.4 Visualizing DNA	442
15.5 Evolvable Fractals	446
Problems	453
Glossary	457
A Probability Theory	463
A.1 Basic Probability Theory.	463
A.1.1 Choosing Things and Binomial Probability	466
A.1.2 Choosing Things to Count	467
A.1.3 Binomial and Normal Confidence Intervals	471
A.2 Markov Chains	473
B A Review of Calculus and Vectors	479
B.1 Derivatives in One Variable	479
B.2 Multivariate Derivatives	482
B.3 Lamarckian Mutation with Gradients	484
B.4 The Method of Least Squares	485
C Combinatorial Graphs	487
C.1 Terminology and Examples	487
C.2 Coloring Graphs	492
C.3 Distances in Graphs	493
C.4 Traveling Salesmen	495
C.5 Drawings of Graphs	495

