

Contents

Preface	xi
Acknowledgments	xiii
1. INTRODUCTION	1
1.1 What is Genetic Programming?	1
1.2 Motivation	5
1.3 Outline	5
2. SURVEY	9
2.1 Introduction	10
2.2 Genetic Algorithms	13
2.3 Genetic Programming	19
2.4 GP Research	26
2.5 GP Applications	36
2.6 Conclusions	42
3. ADVANCED GENETIC PROGRAMMING TECHNIQUES	43
3.1 Background	43
3.2 Tournament Selection	44
3.3 Steady State Populations	45
3.4 Indexed memory	45
3.5 Scalar Memory	45
3.6 Multi-tree programs	46
3.7 Directed Crossover	47
3.8 Demes	49
3.9 Pareto Optimality	53
3.10 Conclusions	57
4. EVOLVING A STACK	61
4.1 Problem Statement	61
4.2 Architecture	65
4.3 Choice of Primitives	65

4.4	Fitness Function	68
4.5	Parameters	70
4.6	Results	71
4.7	Summary	78
5.	EVOLVING A QUEUE	81
5.1	Problem Statement	81
5.2	Architecture	84
5.3	Choice of Primitives	84
5.4	Fitness Functions	87
5.5	Parameters	89
5.6	Automatically Defined Functions	90
5.7	Evolved Solutions – Caterpillar	92
5.8	Evolved Programs – Shuffler	94
5.9	Circular Buffer – Given Modulus Increment	95
5.10	Circular Buffer – Evolving Modulus Increment	102
5.11	Discussion: Building Blocks and Introns	119
5.12	Summary	120
6.	EVOLVING A LIST	123
6.1	Problem Statement	123
6.2	Architecture	124
6.3	Automatically Defined Functions	124
6.4	Choice of Primitives	125
6.5	Fitness Function	129
6.6	Directed Crossover	133
6.7	Parameters	133
6.8	Results	133
6.9	Software Maintenance	139
6.10	Discussion	140
6.11	Conclusions	141
7.	PROBLEMS SOLVED USING DATA STRUCTURES	143
7.1	Balanced Bracket Problem	144
7.2	Dyck Language	149
7.3	Evaluating Reverse Polish Expressions	154
7.4	Work by Others on Solving Problems with Memory	160
7.5	Summary	164
8.	EVOLUTION OF GP POPULATIONS	167
8.1	Price's Selection and Covariance Theorem	168
8.2	Fisher's Fundamental Theorem of Natural Selection	177
8.3	Evolution of Stack Problem Populations	178
8.4	Loss of Variety	183
8.5	Measurements of GP Crossover's Effects	200

8.6 Discussion	202
8.7 Summary	207
9. CONCLUSIONS	209
9.1 Recommendations	210
9.2 Future work	211
References	213
Appendices	237
A–Number of Fitness Evaluations Required	237
B–Glossary	238
C–Scheduling Planned Maintenance of the National Grid	242
C.1 Introduction	242
C.2 The Electricity Transmission Network in Great Britain	242
C.3 The South Wales Region of the UK Electricity Network	244
C.4 Approximating Replacement Generation Costs	246
C.5 The Fitness Function	246
C.6 The Chromosome	248
C.7 Greedy Optimisers	250
C.8 South Wales Problem without Contingencies	251
C.9 South Wales and Genetic Programming	253
C.10 South Wales Problem with Contingencies	262
C.11 Conclusions	265
C.12 Future Work	265
C.13 Using QGAME	266
D–Implementation	267
D.1 GP-QUICK	267
D.2 Coding Changes to GP-QUICK-2.1	268
D.3 Default Parameters	268
D.4 Network Running	269
D.5 Reusing Ancestors Fitness Information	269
D.6 Caches	270
D.7 Compressing the Check Point File	270
D.8 Benchmarks	270
D.9 Code	272
Index	273