Contents

Declaration i
Abstract ii
Acknowledgements iii

Contents iv

Chapter 1. Introduction
1.1 Introduction to Chapter 1
1.2 The Nature of the Problem 1
1.3 Modularity 2
1.4 Aim and Objectives 3
1.5 Novel Aspects of this Research 5
1.6 Thesis Structure 6

Chapter 2. Review of Previous work within the Research Group
2.1 Introduction to Chapter 9
2.2 Single String Evolutionary Techniques 9
2.3 Evolution of Functions within the Animat Nervous System (ANS) 12
   – Lower Layers
2.4 Evolution of Functions within the Animat Nervous System (ANS) 17
   – Upper Layers
2.5 Conclusions Drawn from the Group’s Previous Work 19
2.6 Summary 20

Chapter 3. Evolution and Devolved Action (page numbers)
3.1 Introduction to Chapter 21
3.2 Biological Evolution 22
   3.2.1 Organism at the Cellular Level 25
3.3 Organisation Methods 26
   3.3.1 Modelling Biology 26
6.1 Introduction 73
6.2 Results from Single Functions 73
6.3 Quadruped 91
6.4 Permissible Module Connections 93
6.5 Discussion 98

Chapter 7. Results from Multiple Functions
7.1 Introduction 101
7.2 Evolution of the Body-Plan 101
7.3 Results from Further Degrees of Freedom 102
7.4 Copy And Paste Technique 112
7.5 Dual-Gait Network 114
7.6 Discussion 116

Chapter 8. System Integration
8.1 Introduction 118
8.2 Vision System 118
8.3 Integration of Locomotive with Vision Networks 127
8.4 Discussion 132

Chapter 9. Suggestions for Further Work
9.1 Introduction to Chapter 134
9.2 Other Applications of the Growth Method 134
9.3 Investigations of Further Network Parameters 136
9.4 Other Ideas for Further Work 139

Chapter 10. Conclusions
10.1 Introduction to Chapter 140
10.2 The Project Objectives Revisited 140
10.3 Novel Aspects of this Research 144
10.4 Summary of Suggestions for Further Work 145
10.5 Concluding Remarks 145
References

Appendix A

Papers produced during research

1.1 The Evolution of Modular Artificial Neural Networks for Legged Robot Control

1.2 The Development of Modular Evolutionary Networks for Quadrupedal Locomotion

1.3 Unconstrained Incremental Evolution of Neural Networks for Robot Control

Appendix B

Evolution and Devolved Action

Appendix C

Further Results

Appendix D

Evolutionary Technique flowchart

Appendix E

Description of the Evolutionary ANN