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Editor-in-Chief
Prof. Janusz Kacprzyk
Systems Research Institute
Polish Academy of Sciences
ul. Newelska 6
01-447 Warsaw
Poland
E-mail: kacprzyk@ibspan.waw.pl

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Ian Dempsey
Michael O'Neill
Anthony Brabazon

Foundations in Grammatical Evolution for Dynamic Environments

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Dr. Ian Dempsey
Lead Research Analyst
Pipeline Financial Group, Inc.
60 East 42nd St. Suite 624
New York, NY 10165
USA
E-mail: ian.dempsey@pipelinefinancial.com

Prof. Anthony Brabazon
Head of Research - School of Business
Quinn School
University College Dublin
Belfield, Dublin 4
Ireland
E-mail: anthony.brabazon@ucd.ie

Dr. Michael O'Neill
Director - Natural Computing Research
and Applications Group
School of Computer Science and
Informatics
University College Dublin
Belfield, Dublin 4
Ireland
E-mail: m.oneill@ucd.ie

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Preface

Dynamic environments abound and offer particular challenges for all optimisation and problem solving methods. A well-known strategy for survival in dynamic environments is to adopt a population-based approach. Rather than maintaining a single candidate solution, a population of candidate solutions is employed. This allows a diversity of potential solutions to be maintained, which increases the likelihood that a sufficient solution exists at any point in time to ensure the survival of the population in the long term. Dynamic environments can exhibit different types of change that can be abrupt and random, cyclical, or the product of complex relationships. The changes might range from relatively small smooth transitions to substantial perturbations in all aspects of the domain.

Natural Computing (NC) has given rise to a family of population-based algorithms that exhibit varying degrees of success in solving problems in dynamic environments. It is natural to turn to algorithms which are inspired by the natural world when one wishes to solve problems in the natural world. In particular, biological evolution has given rise to effective problem solvers which survive in complex dynamic environments. Without natural evolution, the inspriation for evolutionary compuation, we would not have any of the other NC algorithms such as neurocomputing, immunocomputing, sociocomputing and grammatical and developmental computing; they are inspired by the products of the biological evolutionary process acting in a dynamic environment.

In this book we focus on the first steps in the extension of a grammar-based form of Genetic Programming, Grammatical Evolution, in order to improve its ability to solve problems in dynamic environments. A relatively recent, powerful, addition to the stable of Evolutionary Computation, Grammatical Evolution (GE) adopts BNF grammars for the evolution of variable length programs. Thus far, there has been little study of the utility of GE in dynamic environments. **Foundations in Grammatical Evolution for Dynamic Environments** is the second book to be published on Grammatical Evolution, and it has been six years since *Grammatical Evolution:*

Evolutionary Automatic Programming in an Arbitrary Language appeared. A comprehensive analysis of prior work in EC and GE in the context of dynamic environments is presented. From this, it is seen that GE offers substantial potential due to the flexibility provided by the BNF grammar and the many-to-one genotype-to-phenotype mapping.

Subsequently, novel methods of constant creation are introduced that incorporate greater levels of latent evolvability through the use of BNF grammars. These methods are demonstrated to be more accurate and adaptable than the standard methods adopted.

Through placing GE in the context of a dynamic real-world problem, the trading of financial indices, phenotypic diversity is demonstrated to be a function of the fitness landscape. That is, phenotypic entropy fluctuates with the universe of potentially fit solutions. Evidence is also presented of the evolution of robust solutions that provide superior out-of-sample performance over a statically trained population.

The findings in this study highlight the importance of the genotype-to-phenotype mapping for evolution in dynamic environments and uncover some of the potential benefits of the incorporation of BNF grammars in GE.

New York & Dublin,
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Ian Dempsey
Michael O'Neill
Anthony Brabazon

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To My Parents
ID

To Gráinne, Aoife and Michael J.
MON

To Maria
AB

Contents