Genet Program Evolvable Mach (2016) 17:193–195
DOI 10.1007/s10710-016-9266-8

BOOK REVIEW

Anthony Brabazon, Michael O'Neill, Sean McGarraghy: Natural computing algorithms

Springer, 2015, 554 pp, ISBN: 978-3-662-43631-8

Simone A. Ludwig[1]

Published online: 9 March 2016
© Springer Science+Business Media New York 2016

The Natural Computing Algorithms book by Anthony Brabazon, Michael O'Neill, and Sean McGarraghy consists of eight parts of which each part describes several related natural computing algorithms. Each part starts with the natural phenomena, which inspired the algorithm, followed by a description of the canonical algorithm, and a description of the most famous variants and improvements. The very first chapter of the book provides an overview of natural computing algorithms and describes the structure of the book, which allows the reader to get an idea of what can be expected.

The first part entitled *evolutionary algorithms* includes chapters introducing evolutionary computing, genetic algorithms, extensions to the genetic algorithm, evolutionary strategies and evolutionary programming, differential evolution, and genetic programming. This part covers the different algorithms that are inspired by the natural processes of evolution, introduces pivotal concepts in the design of natural computing algorithms including choice of representation, diversity generation mechanisms, and the selection of an appropriate fitness function. It allows the most important concepts to be introduced before they are applied in the remaining chapters. A good number of examples are used to explain the concepts in more detail.

The second part is on social computing and includes chapters on *particle swarm optimization*, *ant algorithms*, *foraging algorithms*, *bacterial foraging algorithms*, and other social algorithms. It describes social algorithms that are inspired by the social behaviors of natural systems. In particular, these algorithms use swarm

✉ Simone A. Ludwig
simone.ludwig@ndsu.edu

[1] Department of Computer Science, North Dakota State University, 1320 Albrecht Blvd., Quentin Burdick Bldg. 258, Fargo, ND 58102, USA

behavior whereby each individual in the swarm learns from their own experience as well as from the experience of the other swarm members. These algorithms model flexibility, robustness and self-organization as it appears in the natural world. The particle swarm optimization algorithm and the ant algorithm are described in detail. This provides a good foundation for understanding the other algorithms, such as glowworm swarm and bee algorithms. Again examples are provided to make the ideas clearer.

Part three is dedicated to *neurocomputing* and includes neural networks for supervised and unsupervised learning, and neuroevolution. Neurocomputing algorithms take inspiration from the human brain, which is considered as a vast, interconnected parallel processing system. Although each single neuron does not contribute very much to the overall processing, it is the one hundred billion of neurons that solve very sophisticated tasks, such as recognizing patterns and learning specific tasks. Artificial neural networks (in short neural networks) are usually applied to different learning tasks such as prediction, clustering, and classification. In this part of the book, neural network models for supervised learning including the multi-layer perceptron are described first, followed by the unsupervised learning models such as self-organizing maps, and adaptive resonance theory networks. The last chapter in this part of the book is dedicated to neurocomputing. It outlines different evolutionary methods that are used for model building in neural networks. It gives good coverage of the most important algorithms and includes examples.

The fourth part is the smallest part of the book and describes *immunocomputing* and *artificial immune systems*. It introduces algorithms that are inspired by the immune system of vertebrate animals. There are currently two lines of research. (1) The modeling and simulation of the immune system so that new algorithms can be developed. (2) The use of immune system metaphors that influence the development of computational algorithms, which are the focus of the following chapters. Artificial immune system algorithms can be grouped into four categories: (1) negative selection, (2) clonal expansion and selection, (3) network theory algorithms, and (4) danger theory. However only (1), (2) and (4) are described in detail. They cover the negative selection algorithm that can be used for anomaly detection and classification, the clonal selection algorithm that is used for optimization and classification, and danger theory that can be applied to anomaly detection.

Developmental and *grammatical computing* is described in the fifth part of the book. This part introduces developmental and grammatical computing, grammar-based and developmental genetic programming, grammatical evolution, tree-adjoining grammars and genetic programming, and genetic regulatory networks. The first chapter in this part introduces developmental computing with emphasis on grammatical computing, which uses grammars to create interesting structures. Grammatical computing describes algorithms that are inspired by the underlying formal representation of a grammar. The genetic algorithm and the particle swarm algorithm optimize parameters within a specific predefined model structure, whereas grammatical computing allows the automatic generation of both the model structure as well as the appropriate parameters for that model. The algorithms described are

Lindenmayer systems and grammar-based approaches to genetic programming, grammar-guided GP, grammatical evolution, and tree-adjoining G3P.

Part six is on physical computing and includes the introduction to *physically inspired computing*, and *quantum inspired evolutionary algorithms*. This part starts off with a description of physical phenomena that inspired these algorithms. These include simulated annealing, simulated quantum annealing, and constrained molecular dynamics. Furthermore, a chapter is dedicated to quantum inspired evolutionary algorithms.

In the seventh part of the book other paradigms are outlined, including *plant-inspired algorithms*, and *chemically inspired algorithms*. The plant inspired algorithm chapter outlines a variety of plant behaviors (foraging, plant-level coordination) of which several could inspire new designs of computational algorithms. This is followed by plant-inspired algorithms (plant propagation algorithm, plant growth simulation algorithm, root-swarm behavior algorithm). The chapter on chemically inspired algorithms contains a description of the chemical reaction optimization algorithm.

The last part of the book is dedicated to the *future of natural computing algorithms* with a brief outlook on possible research endeavors. This last chapter outlines the open issues such as hybrid algorithms, benchmarks and scalability, and parameter-free algorithms. These are potential areas, which might drive natural computing algorithms research forward.

I very much enjoyed reading this book and found it to be very comprehensive, well-structured, and well-written. It provides good coverage of natural computing approaches as well as a thorough description of each algorithm with its variants. Each chapter also provides a description of the relationship between Nature and the algorithms. The algorithms described in the first two-thirds of the book I was familiar with, the last third was new to me, however, I found the algorithms to be described clearly and found it an interesting read. I believe the book is very suitable as a textbook for a graduate student course as well as a self-study guide for research students, since there are a good number of examples provided throughout. Furthermore, the algorithm descriptions, figures and tables facilitate the learning of the different concepts. In addition, the 684 references allow the reader to read up on more details and on the different variants of the algorithms.