

Cellular Genetic Algorithms

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Professor Ramesh Sharda
Oklahoma State University

Prof. Dr. Stefan Voß
Universität Hamburg

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Enrique Alba and Bernabé Dorronsoro

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Enrique Alba
Universidad de Málaga
Málaga, Spain
eat@lcc.uma.es

Bernabé Dorronsoro
Universidad de Málaga
Málaga, Spain
bernabe@lcc.uma.es

Series Editors

Ramesh Sharda
Oklahoma State University
Stillwater, Oklahoma, USA

Stefan Voß
Universität Hamburg
Germany

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To my son Enrique and my daughter Ana,
two nice cellular conformations
Enrique Alba

To Patricia and my family
Bernabé Dorronsoro

Preface

This book is the result of an effort to create very efficient search algorithms with a bound cost in their performance and their implementation. Solving optimization and learning problems in academy and industry is of major importance nowadays, not only in computer science, but also in operations research, mathematics, and in almost any domain in daily life: logistics, bioinformatics, economy, telecommunications...

In this context, the research activity on metaheuristic algorithms for solving complex problems is not surprisingly rising in these days. The reason for that is that we are continuously facing new engineering problems which demand more sophisticated solvers. Among the many families of metaheuristics, the application of Evolutionary Algorithms (EAs) has been especially intense during this last decade. These algorithms are usually employed to solve problems of high dimensionality such as constrained optimization tasks, in the presence of noise, having a high degree of epistasis and multimodality.

The behavior of an EA when solving problems is given by the balance they maintain during the search between the *exploration* (diversification) of new solutions and the *exploitation* (intensification) in the space of solutions to the problem. The result of this tradeoff between diversification and intensification of the search is the true key point giving birth to useful tools. With this book, we stress on the proposal of a single family of algorithms which naturally and easily can be tuned to deal with these two forces during their search for a solution. This will endow the reader with a powerful tool to quickly tackle new domains while still using and retaining part of the implementation and knowledge gained with these algorithms.

Traditionally, most EAs work on a single population of candidate solutions (*panmictic* EAs). In this book we explore in depth the benefits of structuring the population by defining neighborhoods on it. The pursued effect is to longer maintain the diversity, thus improving the exploration capabilities of the algorithm, while the exploitation can be easily strengthened by adding local search or many other means. In most cases, these algorithms outperform their equivalent panmictic counterparts in efficiency and accuracy. Among structured EAs, distributed and cellular EAs are the most well known ones. In the book we develop further in the case of cellular EAs (cEAs), where the population

is structured by using the concept of neighborhood much in the way that cellular automata do (hence their name “cellular”), so that individuals can only interact with their closest neighbors in the population. Cellular EAs are not so well known as distributed EAs, but their performance is really impressive and merits a closer look to make the community aware of their power.

This book is targeted to the field of using structured populations in cEAs, especially dealing with cellular genetic algorithms (cGAs), the most popular family of EAs. Specifically, all the work in this book is based on exploring new proposals resulting from extending cGAs to different domains: hybridization, memetics, parallelism, hierarchies, inexpensive self-tuning, probability distributions, or even multi-objective cGAs (wherein the optimization of more than one—usually conflicting—objective is considered). All our proposed new cGAs are compared in this work versus both a canonical cGA and to state-of-the-art algorithms for a plethora of complex optimization problems belonging to the fields of combinatorial, integer programming, continuous, or multi-objective optimization. Our goal is not only to show new models, but also to solve existing problems to the state of the art solutions and beyond, when possible.

The reader can find some amazing starting ideas for numerous new research lines, either from the point of view of new algorithms as from the viewpoint of complex applications. The book can be used for a course on cGAs and also for basic/advanced research in labs. Readers can use it as a whole, and then learn on the many extensions of cGAs to lots of fields, or either can address a given chapter, and get deeper into the details of one algorithm or application.

We are providing a freely available software on the Internet written in Java (JCell) to reproduce our results and to allow readers quickly prototyping new tools for their domain. The java framework Jcell is available at <http://neo.lcc.uma.es/Software/JCell>, and has been developed to be easily extensible and to reduce the learning curve of the user. Since it is written in Java, users can readily deploy it on any computer; the software is at present being used by many international teams with high success.

With this book we think to have put in a single volume a great deal of the knowledge on cellular GAs; the book contains some fundamental theory on cGAs as well as actual competitive algorithms, all sharing some features that will foster their utilization and comprehension in future unseen applications. We really hope that this book could be of any help to the reader in his/her own domain.

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