

Preface

The swarm intelligence optimization method is used to study bio- or non-bio-inspired and population-based iterative algorithms for seeking the intrinsic cooperative mechanism in a swarm. It has recently attracted a great deal of attention from researchers from different fields and diverse domains. Many novel algorithms and their efficient improvements have been proposed continuously. The swarm intelligence optimization method is increasingly becoming one of the hottest and most important paradigms under the big umbrella of evolutionary computation (EC).

Inspired by the fireworks explosion in the night sky, fireworks algorithm, abbreviated as FWA, was proposed by the author in 2010. FWA is a swarm intelligence optimization algorithm, which seems effective at finding a good enough solution to the global optimum of a complex optimization problem. In FWA, as a firework explodes, a shower of sparks is shown in the adjacent area. These sparks explode again and generate other showers of sparks in a smaller area. Gradually, the sparks search the whole solution space in a fine structure and focus on a small region to eventually find (a) good enough solution(s).

To my memory, on the night of the Eve of the 2006 Chinese Lunar Year, as the municipality authorities of Beijing lifted the ban on fireworks during that Spring Festival, people in Beijing set off a large amount of fireworks with sparks of diverse colors which lighted up the dark sky in a variety of beautiful patterns.

While I stared at the glorious scene and colorful patterns for a long time, suddenly an idea came to my mind that the way fireworks explode may be an efficient and effective way or strategy to search for a potential good solution in a vast solution space. Such a search strategy would be different from the established ones in the EC community. Since then I began to study this explosion-like search method.

Like other practical optimization algorithms, FWA is able to fulfill three user requirements given by Storn and Price in 1997. First of all, FWA can process linear, nonlinear, and multi-model test functions. Second, FWA can be parallelized for tackling complicated real-world problems. Third, FWA has good convergence properties and can always find good enough solution(s) for a global minimization problem.

As mentioned above, the motivation for studying FWA is to seek an efficient and effective method with a novel searching mechanism for addressing a variety of complex optimization problems, especially multi-modal optimization problems.

There are three reasons that drove me to publish such a monograph based on our latest research work. The first is that the FWA, with characteristics of explosive ability, randomness, implicit parallelism, instantaneity, and diversity, is a new explosive searching manner to find the global optimum of a complex problem, which considerably enriches and promotes the study of swarm intelligence. The second reason is that the FWA and its variants show their stable convergence and superior performance compared to the standard particle swarm optimization (SPSO) and the latest version of SPSO (SPSO2011) in terms of extensive experiments on the 28 benchmark functions at IEEE CEC2013. The third reason is that the FWA is pretty suitable for multiple-modal optimization functions which will find a wide range of applications in the real world. In this regard, a number of practical applications (including, NMF solving, Spam detection and filtering, JSP, to name a few) based on the FWAs are listed in application chapters of the monograph. Therefore, the FWA provides a brand new way to search the global optimum of complex optimization problems. The current FWA and its applications prove that it can be used to solve many complex optimization problems effectively. Furthermore, the FWA can be also parallelized and is thus suitable to deal with big data problems. Whether for theoretical or applied research, the FWA is worth researching on and can bring great scientific and economic benefits.

This book is the first monograph focused on FWA based on a number of academic papers published primarily by the author and his guided students and team members, and is intended to systematically and completely summarize the most important research work on FWA till date, including FWA's basic principle and implementation, its modeling and theoretical analysis, its most important improvements, and several successful applications.

I hope this book would shape the research on FWA appropriately and can show a complete picture of FWA for interested readers and newcomers who may find many algorithms in the book that can be directly used in their projects on hand without any modification; furthermore, some algorithms can also be viewed as a start point for some active researchers to work on.

This book is primarily intended for researchers, engineers, graduates, and senior undergraduates with interests in novel swarm intelligence algorithms such as fire-works algorithms and its applications. The structure of the contents of this book is organized in a manner from bottom to top or from simple to complex. In order to understand the contents of this book, the readers must have the fundamental skills of digital iterative computing, artificial intelligence, computational intelligence as well as pattern recognition.

In addition, the author presents many newly proposed FWAs in didactic approach with detailed materials and shows their excellent performance using a number of complete experiments and comparisons with state-of-the-art swarm-based algorithms. Furthermore, a collection of resources, source codes, and references of FWA is also provided in the book or accompanied with some webpages

that are available and ready for readers to download freely in an easy-to-use manner at <http://www.cil.pku.edu.cn/research/fwa/resource.html>.

Specifically, this monograph is organized into four parts for easy reference.

Part I is the fundamental and basic theory, which is consisted of three chapters, forming the most substantial theoretical analysis part of this book, including introduction, basic principle, theories and implementation of FWA, modeling and theoretical analysis of FWA, as well as studying the effects of different types of random number generators on the performance of FWA.

Part II is FWA variants, which groups together the most important FWA variants so far, consisting of seven chapters each of which describes one kind of recent significant improvements in FWA. Since the invention of the Fireworks Algorithm (FWA) in 2010, it has attracted a lot of attention in the community of swarm intelligence (SI). All the improvement work on FWA can be classified into two aspects, one, based on working on the limitations of FWA, and the other, its hybridization with other algorithms.

In Part III on advanced topics on FWA, four chapters are included to present some advanced topics in the research on FWA recently, including FWA for multi-objective optimization (MOO), discrete FWA (DFWA) for combinatorial optimization, and GPU-based FWA for parallel implementation of FWA.

Part IV shows how fireworks algorithms can be applied to various applications in different areas. These applications include traditional pattern recognition problems (nonnegative matrix factorization, document clustering, spam detection, and image recognition), complex model estimation problem (seismic inversion), and emerging swarm robotics searching problem. These applications sit in areas that differ greatly from each other and have different requirements for optimization algorithms. The fireworks algorithm can solve these problems successfully, which illustrates that the algorithm can be adapted to different requirements in real-life applications. These applications are reported for instances that might bring insights into more and more real-world applications of FWA in the future.

Due to my limited specialty knowledge and capability, a few errors, typos, inappropriateness, and inadequacy are present in the book, for which critical reviews, constructive comments, and valuable suggestions from interested readers and active researchers are warmly welcome. All comments and suggestions should be sent to [ytan\(AT\)pku.edu.cn](mailto:ytan(AT)pku.edu.cn) for justifying whether or not they will be adopted in a future revision according to their validations and correctness. Finally, I would here like to deliver my faithful and heartfelt thanks to all who gave and will give me help in improving the quality of this book in advance.

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