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Aziz Ouaarab

Discrete Cuckoo Search for Combinatorial Optimization

 Springer

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Preface

Since the first appearance, discrete cuckoo search for the traveling salesman problem has attracted attention of several researchers, and Ph.D. and graduate students. I have received many emails to explain how DCS works and to share the computer code of DCS, and respectively, all the contributions presented in this book. For this reason, I have then reported the description with examples of implementation and computer code on how CS is adapted to solve different combinatorial optimization problems.

The book starts by the theoretical sides in order to present the main ideas that guide the conception of the approach from how it presents the solution and how it changes it, to applying advanced strategies such as intensification/diversification, Lévy flights' displacement, and population smart cuckoo search process. Adapting CS to a set of problems is also presented with sufficient details.

This book has as the main objective facilitating the reuse of CS to be applied in different combinatorial optimization problems. It represents a useful tool for both researchers and students to solve other problems with less adaptation constraints. In addition, its simplified computer code version can be easily improved and designed to be reused.

Marrakech, Morocco
February 2020

Aziz Ouabarab

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About the Author

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Acronyms

ABC	Artificial Bee Colony
ACO	Ant Colony Optimization
BCO	Bee Colony Optimization
Bkv	Best known value
COP	Combinatorial Optimization Problem
CS	Cuckoo Search
CX	Crossover
DCS	Discrete Cuckoo Search
DG	Distributed Generation
FA	Firefly Algorithm
GA	Genetic Algorithms
gBest	global Best
I/D	Intensification/Diversification
JSSP	Job Shop Scheduling Problem
lBest	local Best
OR-Library	Operations Research Library
pBest	particle Best
PSO	Particle Swarm Optimization
QAP	Quadratic Assignment Problem
QAPLIB	Quadratic Assignment Problem Library
RK	Random Key
RKCS	Random-Key Cuckoo Search
TSP	Traveling Salesman Problem
TSPLIB	Traveling Salesman Problem Library

Chapter 1

Introduction



1.1 General Introduction

The need to optimize, plan, or make decisions in real time is everywhere, even in our daily lives. At all moments and situations, we are obliged to make a decision among many options. The problem is that sometimes our decision depends on a multitude of parameters and constraints, which makes the verification of all possible choices more difficult. Replacing the decision-making context of our daily lives by that of large companies and mega-industries, makes gains, and losses increase proportionally. Dealing with these optimization problems is done by using a variety of methods that perform different tools. These methods can be classified by considering two important performance measures: computation time and solution quality. Methods which consume less computation time are relatively more forgiving with the optimality regarding the solution quality. On the other side, methods requiring high-quality solutions are qualified as greedy, in terms of calculation time. The optimality and the calculation time are mainly linked to the performance of the method and the robustness of existing material resources. This situation requires an optimization of the problem conception and the behavior of methods vis-à-vis limitations caused by the hardware.

The nature of the optimization problems can be associated with that of their search/solution space. In general, there are two types of search spaces: continuous and discrete (or combinatorial) space. The first is the space containing solutions characterized by their continuous or real variables, while the second is a set of solutions of discrete variables. A large part of problems in planning, logistics, transport, finance, and manufacturing, which are of discrete or combinatorial nature, represent a real challenge of calculation for algorithms developed to solve them, knowing that the size of these problems exceeds, more and more with industry development. Indeed, several optimization problems are apparently simple, but their difficulty increases exponentially with their size. This makes the choice to search and verify each combination (solution) not practical.

Talking complexity, NP-hard problems (Arora and Barak 2009) belong to the class of problems that attracts researchers in the field of optimization to propose new efficient approaches. However, no algorithm is effective in dealing with this type of problems. The need to quickly find a good quality solution favors the appearance of approximate or stochastic algorithms. In this context, metaheuristics (Blum and Roli 2003; Glover and Kochenberger 2003) have shown their high performance for a wide variety of optimization problems and have more advantages compared to traditional algorithms, such as the ability to deal with high levels of complexity, and to be adapted (with a set of constraints) to several problem models and their application in several real-world areas, starting from operational research, passing through engineering and artificial intelligence (Yang and Gandomi 2012; Yang et al. 2013; Gandomi et al. 2011, 2012), where there is a need for optimize digital functions, and systems containing a large number of parameters to be tuned simultaneously.

1.2 Challenges in Metaheuristics

Metaheuristics are a family of algorithms that carries out a search strategy which combines an exploration of the search space on its global scale, with an intensified exploitation in regions considered promising. They employ one or a population of interactive agents for iterative search, of new potentially better or optimal solutions. The majority of recently designed metaheuristics are inspired by nature (Yang and Deb 2009; Yang 2009), imitating biological phenomena (Wang et al. 2000), physical (Van Laarhoven and Aarts 1987), or social (Rao et al. 2011). Among the strong points of metaheuristics, we cite their relative ease of implementation, practically adaptable to several types of problems while producing solutions of good quality or even of optimal quality in a reasonable time. While searching scholastically toward a global optimum, they scan the search space (of solutions) by moving from one solution to another in the hope of finding better. In order to be more productive in their movement, metaheuristics need to learn about the spatial topology of the problem, starting with the notion of neighborhood. Two so-called neighboring solutions in the search space, when they contain coordinates of relatively close values and their quality values, are also close to each other. This condition is achievable in the majority of continuous optimization problems. However, in the case of combinatorial optimization, the debate remains open. The displacement, in continuous space, of the current solution toward a neighboring solution is performed by a change in its coordinates. This displacement generally produces a small difference between the two qualities of the current solution and its neighbor. On the other hand, a small change on a combinatorial solution space can lead to a “neighboring” solution of remarkably different qualitative values. This explains the possibility of finding the optimal solution and a poor quality solution in the same neighborhood. Most of metaheuristics are developed mainly to solve continuous optimization problems. All these metaheuristics that deal with combinatorial optimization problems are attempting to be adapted to this category of problems. To go directly to the heart of the problem of