Chapter 19

A Survey of the Cuckoo Search and Its Applications in Real-World Optimization Problems

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ABSTRACT

The chapter at hand seeks to provide a general survey of the Cuckoo Search Algorithm and its most highlighted variants. The Cuckoo Search Algorithm is a relatively recent nature-inspired population-based meta-heuristic algorithm that is based upon the lifestyle, egg laying, and breeding strategy of some species of cuckoos. In this case, the Lévy flight is used to move the cuckoos within the search space of the optimization problem to solve and obtain a suitable balance between diversification and intensification. As discussed in this chapter, the Cuckoo Search Algorithm has been successfully applied to a wide range of heterogeneous optimization problems found in practical applications over the last few years. Some of the reasons of its relevance are the reduced number of parameters to configure and its ease of implementation.

1. INTRODUCTION

Optimization is a term which has arisen in a natural way from behind multitude of aspects of our daily lives, both at familiar, professional, and scientific levels (Koziel & Yang, 2011). Its practical applications cover a wide range of fields, such as economics, engineering, medicine, agriculture, sports, image processing, data mining, software design, and operations research, among others. For example, determining the shortest path to get to work, selecting the most suitable place to set up a new logistic infrastructure, choosing the best portfolio in such a way that the expected value is as high as possible, or even calculating the optimal timing of organ transplants. In all of these cases and from a mathematical perspective,

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the goal is to select the best element from a given set of available alternatives according to one or several criteria. This means selecting that element which maximizes or minimizes a given mathematical function.

Nature has become an excellent source of inspiration for the conceptual development of efficient solving methods to tackle optimization problems. In this regard, nature-inspired algorithms are a revolutionary class of approximate solving techniques based on the principles found behind some nature processes. Over the last years, multitude of meta-heuristic algorithms underpinned by diverse nature-inspired paradigms have been already proposed in the scientific literature with the aim of solving a wide range of real-world optimization problems. Due to their numerous and successful application contexts, some of the most outstanding nature-inspired meta-heuristic algorithms are Genetic Algorithms (Holland, 1975), Ant Colony Optimization Algorithms (Dorigo et al., 1996), Particle Swarm Optimization Algorithms (Kennedy and Eberhart, 1995), and Artificial Bee Colony Algorithms (Karaboga, 2005), among others. These optimization techniques mimic the evolutionary ideas of natural selection and genetics, the behavior of ants when seeking a path between their home colony and a source of food, the behavior of particles in nature, and the behavior of a honey bee swarm, respectively.

Broadly speaking, the popularity of nature-inspired algorithms lies in the fact that current practical optimization problems are nowadays becoming increasingly more complex in terms of dimensions, constraints, dynamism, uncertainty, etc. In this regard, nature-inspired algorithms are usually able to identify promising regions within the search space of a given optimization problem and extract high-quality solutions by means of a reasonable amount of computational time. However, it is worth mentioning that these optimization techniques have certain limitations that must be appropriately analyzed before their effective application in practice. In general terms, they present an asymptotic convergence, and therefore they no guarantee to identify the optima solutions of all the optimization problems in finite computational time. Also, the performance of these techniques is highly dependent on the values of its internal running parameters. In addition, the number of parameters to configure is high in some techniques. Lastly, some of these techniques are computationally very expensive, and consequently they cannot be easily adapted to address real-time or dynamic optimization problems.

The present chapter is aimed at providing to the reader an overview of a recent nature-inspired meta-heuristic termed Cuckoo Search and the main variants of it published in the scientific literature so far. In this regard, its key components are analyzed, whereas, due to its high efficiency in computational terms, some of its most successful application contexts in the real world are also discussed. As pointed out in this chapter, this optimization technique presents some of the most outstanding advantages associated with nature-inspired methods while the aforementioned limitations are somewhat mitigated.

The remainder of the chapter at hand is organized as follows. Firstly, Section 2 describes the Cuckoo Search from a general point of view. Afterwards, some of the most relevant variants of the Cuckoo Search are discussed in Section 3. Later, a brief overview of successful applications of this optimization technique in a wide range of fields is presented in Section 4. Finally, Section 5 draws some concluding remarks from the chapter.