Cuckoo Search Algorithm

Ömür Tosun
Akdeniz University, Turkey

INTRODUCTION

Sometimes there are difficult optimization problems that it is impossible to find the best strategy or perhaps even not exist at all. For this kind of problems, researchers developed efficient methods called metaheuristic algorithms to find near optimal solutions under an acceptable run-time. Since there isn't any single metaheuristic algorithm to solve all optimization problems with different types or structures, researchers develop new metaheuristic algorithms with an increasing pace. Most of these algorithms are nature or bio-inspired, mimicking the successful characteristics of nature. Cuckoo search (CS) is one of the relatively new algorithms proposed by Yang and Deb (2009).

BACKGROUND

The metaheuristic algorithms use two basic strategies searching for the global optimum; exploration and exploitation. While the exploration process succeeds in enabling the algorithm to reach the best local solutions within the search space, the exploitation process is the ability to reach the global optimum solution which is likely to exist around the local solutions obtained. A metaheuristic algorithm must be able to rapidly converge to the global optimum solution with the related objective function. Furthermore, the run-time required by a metaheuristic algorithm to reach to global minimum and the total calculation amount must be at acceptable levels for practical applications. The algorithmic structure of a metaheuristic algorithm is desired to be simple enough to allow for its easy adaptation to different problems. Finally, it is desired that the metaheuristic algorithm has no or very few algorithmic control parameters except the general ones (i.e., size of population, total number of iterations, problem dimension) of the population based optimization algorithms (Civicioglu and Besdok, 2013).

The increasing popularity of metaheuristics and swarm intelligence has attracted a great deal of attention in engineering and industry. One of the reasons for this popularity is that nature inspired metaheuristics are versatile and efficient, and such seemingly simple algorithms can deal with very complex optimization problems. Metaheuristic algorithms form an important part of contemporary global optimization algorithms, computational intelligence and soft computing. Nature-inspired algorithms often use multiple interacting agents. A subset of metaheuristics are often referred to as swarm intelligence based algorithms, and these algorithms have been developed by inspiring from the swarm intelligence characteristics of biological agents such as insects, birds, fish, humans and others. For example, particle swarm optimization was based on the swarming behavior of birds and fish, while the firefly algorithm was based on the flashing pattern of tropical fireflies, and cuckoo search algorithm was inspired by the brood parasitism of some cuckoo species (Yang, 2012; Fister et al., 2014).

MAIN FOCUS

Modern metaheuristic algorithms have been developed with an aim to carry out global search with three main purposes: solving problems faster, solving large problems, and obtaining robust algorithms. The efficiency of metaheuristic algorithms can be attributed to the fact that they

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imitate the best features in nature, especially the selection of the fittest in biological systems which have evolved by natural selection over millions of years. Cuckoo search is a new metaheuristic search algorithm which is based on the obligate brood parasitic behavior of some cuckoo species in combination with the Lévy flight behavior of some birds and fruit flies. It is developed by Yang and Deb (2009) and the preliminary studies show that it is very promising and could outperform existing algorithms such as genetic algorithms and particle swarm optimization (Gandomi et al., 2013).

Cuckoo Search Algorithm

Cuckoo search algorithm is a relatively new search algorithm inspired by the obligate brood parasitism of some cuckoo species by laying their eggs in the nests of host birds. Some cuckoos have evolved in such a way that female parasitic cuckoos can imitate the colors and patterns of the eggs of a few chosen host species. This reduces the probability of the eggs being abandoned and, therefore, increases their reproductivity. It is known that several host birds engage direct conflict with intruding cuckoos. In this case, if host birds discover the eggs are not their own, they will either throw them away or simply abandon their nests and build new ones elsewhere. Parasitic cuckoos often choose a nest where the host bird just laid its own eggs. In general, the cuckoo eggs hatch slightly earlier than their host eggs. Once the first cuckoo chick is hatched, his first instinct action is to evict the host eggs by blindly propelling the eggs out of the nest. This action results in increasing the cuckoo chick's share of food provided by its host bird (Walton et al., 2011; Valian et al., 2011; Xing and Gao, 2014).

An important component of a CS is the use of Lévy flights for both local and global searching. The Lévy flight process, which has previously been used in search algorithms in Pavlyukevich (2007), is a random walk that is characterized by a series of instantaneous jumps chosen from a probability density function which has a power law tail. This process represents the optimum random search pattern and is frequently found in nature. When generating a new egg in CS, a Lévy flight is performed starting at the position of a randomly selected egg, if the objective function value at these new coordinates is better than another randomly selected egg then that egg is moved to this new position. The scale of this random search is controlled by multiplying the generated Lévy flight by a step size α (Walton et al., 2013).

Lévy Flight

In nature, animals search for food in a random or quasi-random manner. In general, the foraging path of an animal is effectively a random walk because the next move is based on the current location/state and the transition probability to the next location. Which direction it chooses depends implicitly on a probability which can be modeled mathematically. While flying, some animals and insects follow the path of long trajectories with sudden 90^0 turns combined with short, random movements. This random walk is called Lévy flight and it describes foraging patterns in natural systems, such as systems of ants, bees, bumbles, and even zooplanktons. Mathematical formulation of Lévy flight relates to chaos theory and it is widely used in stochastic simulations of random and pseudo-random phenomena in nature. (Yang and Deb, 2013; Tuba et al., 2012).

$x_i^{(t)}$ is the solution of the *i.* cuckoo in iteration *t*. A new solution $x^{(t+1)}$ for cuckoo *i* is generated using a Lévy flight according to the following equation:

$$x_i^{(t+1)} = x_i^{(t)} + a\,\hat{}\,L\acute{e}vy\left(\lambda\right) \quad (1)$$

where α (α>0) represents a step scaling size. This parameter should be related to the scales of problem the algorithm is trying to solve. In most cases, α can be set to the value of 1 or some other constant. The product ^ represents entry-

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