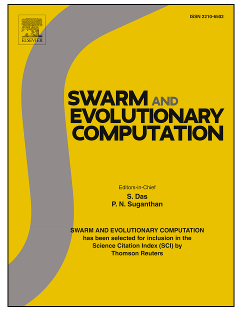

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A Set of New Compact Firefly Algorithms

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***Abstract*– Population-based algorithms are among the most successful approaches to optimization. These algorithms require high computational capacities such as memory storage. During the last decade, an alternative approach, called compact optimization, was developed. In real-valued compact algorithms, the population is represented by a probabilistic distribution function. Real-valued compact genetic algorithm was first developed and then the idea was extended to other population-based algorithms, like differential evolution, particle swarm optimization and teaching-learning-based optimization. In this paper, we introduce a set of new compact firefly algorithms (cFAs) with minimal computational costs. Our primary aim is to reduce the computational capacity and storage required by the classical variants of FA. The proposed approaches lead to the reduction of the complexity of the attraction model used in FA. The proposed cFAs achieve the optimization with a minimal number of attractions. Several propositions are investigated and reported; such as: elitism strategies, Lévy movements, and opposition-based learning. The proposed algorithms consist of: permanent elitism-based compact firefly algorithm (pe-cFA), non-permanent elitism-based compact firefly algorithms (ne-cFA), permanent elitism-based compact Lévy-flight firefly algorithms (pe-cLFA), non-permanent elitism-based compact Lévy-flight firefly algorithms (ne-cLFA), opposition-based compact firefly algorithms (OBcFA) and opposition-based compact Lévy- flight firefly algorithms (OBcLFA). All the known compact algorithms use normal probability of density function (NPDF) to represent the population. In this paper, a new way is investigated. The alternative solution proposed here is based on uniform PDF (UPDF). Thus, two categories of cFAs are presented: NPDF-based cFAs and UPDF-based cFAs. Hence, for each proposed algorithm, two versions are presented and analyzed. The proposed set of twelve algorithms are tested on the IEEE CEC2014 benchmark functions and compared to the state-of-art of compact evolutionary algorithms (cEAs), swarm intelligent algorithms (SIAs), and the most advanced evolutionary algorithms (EAs). The obtained results show that the proposed cFAs are very competitive and that the uniform distribution is very efficient. The case study of this paper concerns the optimal swing-up control of a gymnastic humanoid robot hanging on a bar.**

***Keys words*: compact swarm intelligence; compact representation; optimization; firefly algorithm; humanoid robot; control.**

1. Introduction

Computational intelligence (CI) is a subfield of computer science that uses models, methods and techniques inspired from the behaviors [1, 2] of intelligent biological systems. As the natural evolution has endowed breeds with very processed and sophisticated skills, engineers and scientists take inspiration from nature to develop several powerful and robust algorithms to solve difficult engineering problems. The swarm intelligence (SI), introduced by Gerardo Beni and Jing Wang in 1989 [1], is one of the bionic-based computing domains that consists of the exploitation of some mathematical models inspired from the collective behaviors of species [3]. Each swarm agent, also called particle [4-6], is capable of interacting with its environment and locally with the other particles in its sides. The collective comportment of the decentralized swarm makes it a self-organizing system. The proposed algorithms, inspired by swarms, consist of population-based strategies. The particles abilities, such as extracting information from their environment and sharing it in the group, leads the whole population toward the optimal sub-region of the search space. In the literature, very effective optimization techniques based on swarm intelligent systems have been proposed and this includes ant colonies [7, 8], honey bee colonies [9-11], fish schooling [12], firefly algorithm (FA) [13–15], the cuckoo search [16-18], Physarum Polycephalum algorithm [19], and bat algorithm [20-22].

The firefly algorithm (FA) was introduced by Xin-She Yang at Cambridge University, based on the modeling of the brightness and attractiveness characteristics of the fireflies [14-15]. Like other population-based algorithms, it uses the firefly's positions to represent the temporally found solutions. Each firefly is capable of radiating signals to attract the others towards its own position. The fireflies are assumed bisexual, and the attractiveness is not for sexuality. If the firefly x_i is better than x_j, the x_j will be moved toward x_i. Hence, the best fireflies will attract the others toward them.

Although FA has shown good performance [13, 23], it can be subject to premature convergence [24-26]. Therefore, improving FA's performance was the topic of several contributions. We can cite Lévy-flight FA [27], chaos-based FA [28],