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On a novel multi-swarm fruit fly optimization algorithm and its application ☆

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ABSTRACT

Swarm intelligence is a research field that models the collective behavior in swarms of insects or animals. Recently, a kind of Drosophila (fruit fly) inspired optimization algorithm, called fruit fly optimization algorithm (FOA), has been developed. This paper presents a variation on original FOA technique, named multi-swarm fruit fly optimization algorithm (MFOA), employing multi-swarm behavior to significantly improve the performance. In the MFOA approach, several sub-swarms moving independently in the search space with the aim of simultaneously exploring global optimal at the same time, and local behavior between sub-swarms are also considered. In addition, several other improvements for original FOA technique is also considered, such as: shrunk exploring radius using osphresis, and a new distance function. Application of the proposed MFOA approach on several benchmark functions and parameter identification of synchronous generator shows an effective improvement in its performance over original FOA technique.

1. Introduction

In the last few decades, more and more researches suggest that nature is a great source for inspirations to both develop intelligent systems and provide solutions to complicated problems [1]. Taking animals for example, evolutionary pressure forces them to develop highly optimized organs and skills to take advantages of fighting for food, territories and mates. Some of the organs and skills can be well refined as optimization algorithms, and the evolution is a process to fine-tune the parameter settings in the algorithms [1].

The collective intelligent behavior of insect or animal groups in nature such as flocks of birds, colonies of ants, schools of fish, swarms of bees and termites have attracted the attention of researchers [2]. In recent years, some examples of swarm behavior inspired optimization algorithms are particle swarm optimization (PSO) algorithm [3,4], ant colony optimization (ACO) [5,6], artificial bee colony (ABC) algorithm [7,8], social spider optimization (SSO) [2], artificial fish swarm algorithm [9], firefly algorithm (FA) [10]. Simulations and applications have shown that these swarm behavior inspired meta-heuristics in [2–10] have good search capability as well as potential applications.

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One current trend in swarm behavior research is focusing more on the Drosophila (fruit fly) species [11,12]. Recently, a kind of Drosophila inspired optimization algorithm has been developed, called fruit fly optimization algorithm (FOA) [13,14], which is a novel evolutionary computation and optimization technique. The FOA is a new approach for finding global optimization based on the swarm behavior of fruit fly. The main inspiration of FOA is that the fruit fly itself is superior to other species in sensing and perception, especially in osphresis and vision. The FOA technique has the advantages of being easy to understand and to be written into program code which is not too long. More recently, FOA technique has been applied in several applications, such as swarms of mini autonomous surface vehicles [13], neural network parameters optimization [14–17], PID controller parameters tuning [18], key control characteristics optimization [19] etc. In order to improve the search efficiency and global search ability, several researchers have also presented improved FOA [19–22]. However, for these FOAs, fruit fly swarm will use vision to fly towards so far best smell position, this implies that fruit flies will be around the so far best smell position at a fast speed. The diversity loss occurs when the global optimal is shifted away from a too converged swarm. This kind of swarm behavior is quite similar to being trapped in local optimal or premature in multi-model optimization problems.

This paper presents a variation on the original FOA technique, named multi-swarm fruit fly optimization algorithm (MFOA), employing multi-swarms behavior to significantly improve the performance. In the MFOA approach, several sub-swarms moving independently in the search space with the aim of simultaneously exploring global optimal at the same time, and local behavior between sub-swarms are also considered. In addition, several other improvements for original FOA technique is also considered, such as: shrunk exploring radius using osphresis, and a new distance function. Application of this new MFOA approach on several benchmark functions and parameter identification of synchronous generator shows a marked improvement in performance over original FOA technique.

The rest of this paper is organized as follows. Review of FOA technique is summarized in Section 2. Section 3 describes the motivation and implement of the MFOA approach in detail. In Section 4, the testing of the proposed MFOA approach through benchmark problems and parameter identification of synchronous generator is carried out and the simulation results are compared. Finally, the conclusion is drawn in Section 5.

2. FOA technique

2.1. Swarm behavior of fruit fly

The osphresis organs of fruit fly can find all kinds of scents floating in the air; it can even smell food source from 40 km away. Then, after it gets close to the food location, it can also use its sensitive vision to find food and the company's flocking location, and fly towards that direction too [13]. When a fly decides to go for hunting, it will fly randomly to find the location guided by a particular odor. While searching, a fly also sends and receives information from its neighbors and makes comparison about the so far best location and fitness [13]. If a fly has found its favorable spot, it will then identify the fitness by taste. If the location no longer exists or the taste is 'bitter', the fly will go off searching again. The fly will stay around at the most profitable area, sending, receiving and comparing information with its swarm at the same time [13].

The main idea behind the FOA technique is based upon the Drosophila's biological behavior [13]: (1) The fly flies with Levy flight motion; (2) It smells the potential location (attractiveness); (3) It would then taste. If it is not to its liking (fitness/profitability), it rejects and goes to another location. To the fly, attractiveness is not necessarily profitable; (4) While foraging or mating, the fly also sends and receives messages with its swarm about its food and their mates.

2.2. FOA technique implementation

Based on the food finding characteristics of fruit fly swarm, a kind of FOA technique is proposed in [13,14], which is a novel evolutionary computation and optimization technique. Although the FOAs are inspired by swarm behavior of fruit fly, the implement procedure of FOA in [13] is different from that in [14–18]. This can be considered as two different ways of computing implement for FOA technique. In this paper, we will focus on FOA technique in [14–18] for improvement. The FOA in [14–18] can be divided into several necessary steps and the main steps are described as follows:

Step 1. Random initial fruit fly swarm location as shown in Fig. 1. *Init* X_axis; *Init* Y_axis.

Step 2. Give the random direction and distance for the search of food using osphresis by an individual fruit fly.

$$\begin{aligned} X_i &= X\_axis + RandomValue \\ Y_i &= Y\_axis + RandomValue \end{aligned} \tag{1}$$

where i is the population size of fruit flies.

Step 3. Since the food location cannot be known, the distance to the origin is thus estimated first ($Dist$), then the smell concentration judgment value (S) is calculated, and this value is the reciprocal of distance.