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Development and investigation of efficient artificial bee colony algorithm for numerical function optimization

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ABSTRACT

Artificial bee colony algorithm (ABC), which is inspired by the foraging behavior of honey bee swarm, is a biological-inspired optimization. It shows more effective than genetic algorithm (GA), particle swarm optimization (PSO) and ant colony optimization (ACO). However, ABC is good at exploration but poor at exploitation, and its convergence speed is also an issue in some cases. For these insufficiencies, we propose an improved ABC algorithm called I-ABC. In I-ABC, the best-so-far solution, inertia weight and acceleration coefficients are introduced to modify the search process. Inertia weight and acceleration coefficients are defined as functions of the fitness. In addition, to further balance search processes, the modification forms of the employed bees and the onlooker ones are different in the second acceleration coefficient. Experiments show that, for most functions, the I-ABC has a faster convergence speed and better performances than each of ABC and the gbest-guided ABC (GABC). But I-ABC could not still substantially achieve the best solution for all optimization problems. In a few cases, it could not find better results than ABC or GABC. In order to inherit the bright sides of ABC, GABC and I-ABC, a high-efficiency hybrid ABC algorithm, which is called PS-ABC, is proposed. PS-ABC owns the abilities of prediction and selection. Results show that PS-ABC has a faster convergence speed like I-ABC and better search ability than other relevant methods for almost all functions.

1. Introduction

Optimization problems frequently encountered in multitudinous applications are at the heart of engineering design [1,2], economics [3], statistical physics [4], information theory and computer science, etc. [5–7]. However it is very widely believed that, for many actual optimization problems, searching optimal solutions is very extreme hardness and sometimes completely beyond any current or projected computational capacity. So there has been a growing interest in various algorithms [8,9] developed and investigated for two decades, especially biological-inspired optimization algorithms such as genetic algorithm (GA) [10,11], particle swarm optimization (PSO) [12–16], ant colony optimization (ACO) [17] and artificial bee colony (ABC) [18]. These algorithms have been adopted by researchers so far and are well suited to solve various complex computational problems such as optimization of objective functions [19–21], pattern recognition [22], filter modeling [23,24].

ABC recently proposed by D. Karaboga is a biological-inspired optimization algorithm which mimics the foraging behavior of honey bee swarm. This algorithm has been applied to search an optimum solution in many optimization problems. In some researches, the performance of ABC has already been compared with other search optimization techniques such as (GA), PSO, ACO, Differential Evolution (DE) algorithm. Various numerical benchmark functions, which consist of unimodal and multimodal distributions, are employed to evaluate the performance of ABC. The comparison results showed that ABC can find a better solution, and is more effective than other optimization techniques. The exploration and exploitation are extremely important mechanisms in ABC. However, there are still some insufficiencies, namely, ABC is good at exploration but poor at exploitation and its convergence speed is also an issue in some cases. The exploration process is related to the ability of independently seeking for the global optimum, while the exploitation process is related to the ability of applying the existing knowledge to look for better solutions. In order to further balance and accelerate the two processes, a few modified or improved algorithms [25] based on the foraging behavior of honey bee swarm are proposed in recent years, such as best-so-far ABC [26], gbest-guided ABC (GABC) [27], Bee Swarm Optimization (BSO) [28]. These modified ABCs have better performances than the original ABC.

However, there is no specific algorithm to substantially achieve the best solution for all optimization problems. Some algorithms only give a better solution for some particular problems than others. Hence, searching for a well improved or new optimization method

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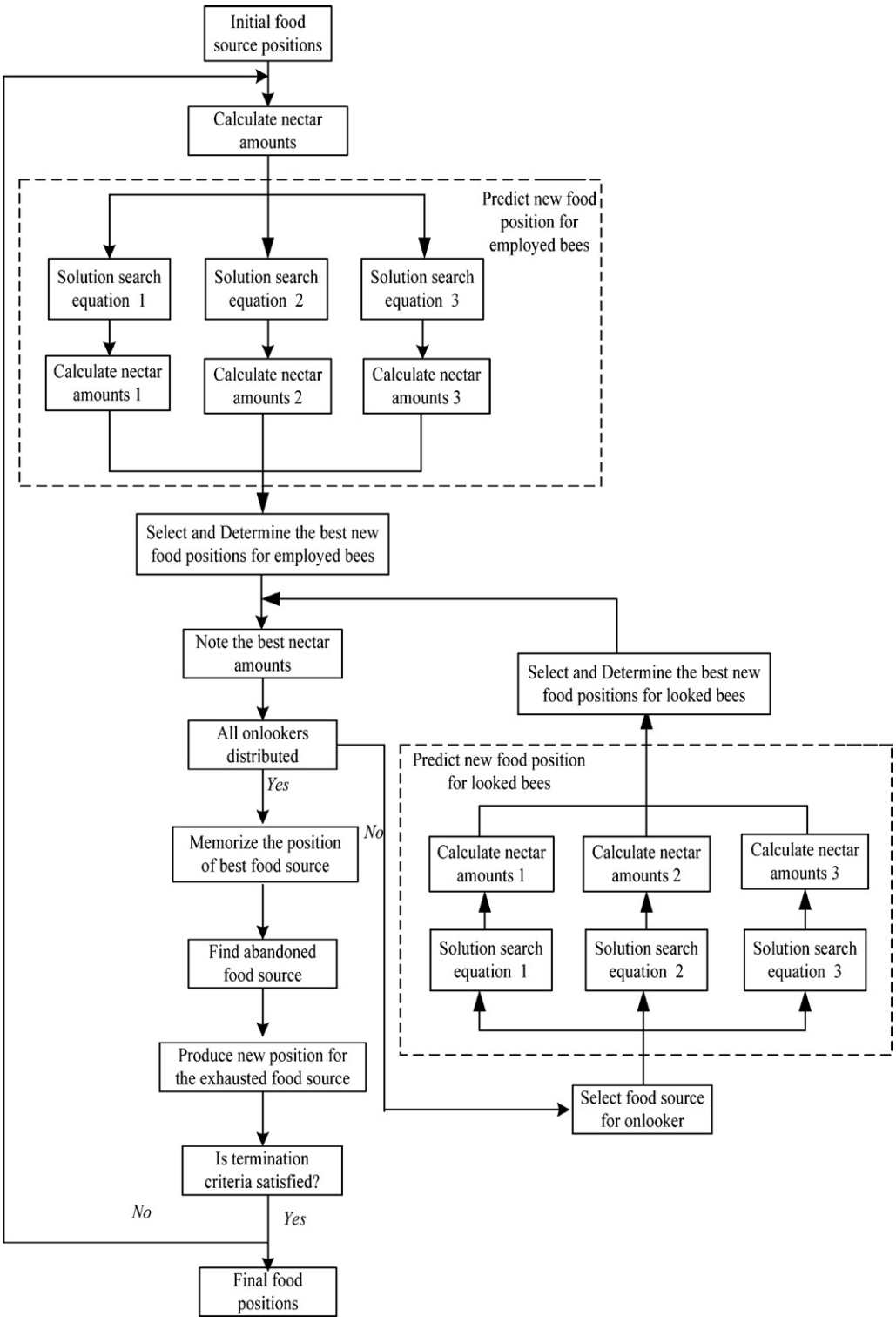

Fig. 1. Flowchart of the PS-ABC algorithm.

is very necessary. In this paper, we propose a high-efficiency ABC method to further improve the performance of ABC. The improved ABC, which is called I-ABC, has an extremely fast convergence speed. There are three major differences between ABC and I-ABC. Namely, the best-so-far solution, inertia weight and acceleration coefficients are introduced to modify the search process, and inertia weight and acceleration coefficients are defined as functions of the fitness. In addition, to further balance the exploitation and exploration processes, the modification forms of the employed bees and the onlooker ones are different in the second acceleration coefficient. Simulation results show that the I-ABC could not only find the global optimal values for many numerical benchmark functions, but also own an extremely fast convergence speed.

However, in only a few cases, the I-ABC traps in local optimal solutions and cannot find better solutions than ABC or GABC. In