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A modified scout bee for artificial bee colony algorithm and its performance on optimization problems

Syahid Anuar [a], **Ali Selamat** [a,b,*], **Roselina Sallehuddin** [a]

[a] *Faculty of Computing, Universiti Teknologi Malaysia, Malaysia*
[b] *UTM-IRDA Digital Media Center of Excellence, Universiti Teknologi Malaysia, Malaysia*

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Abstract The artificial bee colony (ABC) is one of the swarm intelligence algorithms used to solve optimization problems which is inspired by the foraging behaviour of the honey bees. In this paper, artificial bee colony with the rate of change technique which models the behaviour of scout bee to improve the performance of the standard ABC in terms of exploration is introduced. The technique is called artificial bee colony rate of change (ABC-ROC) because the scout bee process depends on the rate of change on the performance graph, replace the parameter *limit*. The performance of ABC-ROC is analysed on a set of benchmark problems and also on the effect of the parameter *colony size*. Furthermore, the performance of ABC-ROC is compared with the state of the art algorithms.

1. Introduction

The ABC algorithm is introduced by Karaboga (2005), based on the foraging behaviour of a honey bees swarm. In ABC, the colony of artificial bees consists of three groups namely employed, onlooker and scout. A food source position represents a possible solution to the problem that is to be optimized and the nectar of a food source corresponds to the quality of the solution represented by the food source. During each cycle, the employed and onlooker bees are moving toward the food sources, thus calculating the nectar amounts and determining the scout bee and then moving them randomly onto the possible food sources. If the solution does not improve by a predetermined number of trials, the food source is abandoned. The number of trials for releasing a food source is equal to the value of *limit* which is an important control parameter of ABC (Karaboga and Gorkemli, 2014). After the *limit* is achieved, the employed bee is converted to a scout to search for new food sources.

The scout bee is an important component to control the exploration process (Karaboga and Basturk, 2008). However,

* Corresponding author at: Faculty of Computing, Universiti Teknologi Malaysia, Malaysia. Tel.: +60 7 5532222, +60 7 5538009; fax: +60 7 5565044. He is also a visiting professor at University of Hradec Kralove, FIM, Center for Basic and Applied Research, Rokitanskeho, 62, Hradec 9 Kralove, 500 03, Czech Republic.
E-mail address: aselamat@utm.my (A. Selamat).
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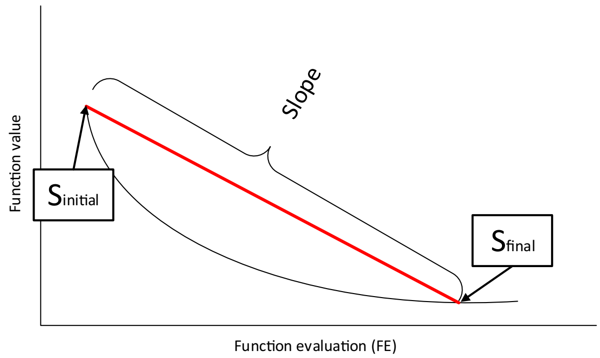

Figure 1 Illustration of slope in graph.

recent studies on ABC show that the scout bee component is redundant and sometimes does not present during the search process (Bullinaria and AlYahya, 2014a,b). As a result, the global exploration does not happen during the process because the global exploration is controlled by the scout bee component (Karaboga and Basturk, 2007). Therefore, we propose a new technique to control the scout bee process.

In this study, we propose a technique to replace the *limit* of the standard ABC algorithm. This technique is based on the changing of slope on the performance graph. The optimization process causes a decrease in the performance graph in case of function minimization and increasing of the performance graph in case of function maximization until the stopping condition achieved. By taking advantage of the changing pattern on the performance graph, we introduce a new technique called rate of change (ROC) to improve the performance of ABC in terms of exploration. The implementation of ROC technique in ABC algorithm is called artificial bee colony rate of change (ABC-ROC). Later, the ABC-ROC will be described in detail and its performance is tested on a set of test problems. The effect of newly added control parameters such as maxROC, maxTrace and maxFlag is investigated. The performance of ABC-ROC is also compared to the state of the art algorithms.

The rest of this paper is organized as follows. Section 2 discusses the literature review on ABC. Section 3 provides an overview of ABC algorithm. Section 4 describes the proposed, ABC-ROC algorithm. Section 5 gives a computational study and discussion, that include the explanation of the problems used in this experiment. Section 6 presents the experimental complexity of ABC and ABC-ROC algorithms. Section 7 presents the experiment on the effect of colony size (CS). Section 8 presents the comparisons of the number of scout bee between ABC and ABC-ROC. Finally, Section 9 concludes this paper and suggests the future direction.

2. Literature review

The standard ABC algorithm has successfully produced good results in the optimization problem because ABC has advantages of memory, local search and solution improvement mechanism (Basturk and Karaboga, 2006; Karaboga and Basturk, 2007, 2008; Zhao et al., 2010; Ozturk and Karaboga, 2011). However, in some cases, researchers found ABC may stuck in local optimum that affects the convergence performance and resulted in uncertainties on the results obtained from the standard ABC algorithm (Luo et al., 2013; Xiang and An, 2013; Kong et al., 2013).

Some researchers argued that the problem arose from the exploration process while other researchers believed that the problems are caused by the exploitation process of ABC. The exploration is the ability to investigate the various unknown region to discover the global optimum in solution space. This ability is performed by the scout bee component (Kong et al., 2013; Karaboga and Basturk, 2007). The exploitation is the ability to apply the knowledge of the previous good solutions to find better solutions. This process done by employed and onlooker bees (Kong et al., 2013; Karaboga and Basturk, 2007). In order to improve the exploration and exploitation process, many changes have been made on the standard ABC algorithm.

Aderhold et al. investigated the influence of the population size of the ABC and proposed two variants of ABC which use new methods for the position update of artificial bees (Aderhold et al., 2010). Stanarevic et al. proposed a modified ABC which includes "smart bee" that uses its historical memories of location and quality of the food source (Stanarevic et al., 2010). Lei et al, discovered that original ABC suffers from low precision and efficiency in solving optimization problems thus introduced a modification of the original ABC by adding an inertial weight which was inspired by particle swarm optimization (Lei et al., 2010).

Table 1 Test problems.

Test function	C	D	Interval	Min	Formulation
Ackley	MN	30	[−32,32]	$F_{min} = 0$	$f(x) = -20\exp\left(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}\right) - exp\left(\frac{1}{n}\sum_{i=1}^{n} cos(2\pi x_i)\right) + 20 + e$
Branin	MS	2	[−5,10] × [0,15]	$F_{min} = 0.398$	$f(x) = (x_2 - (5.1/4\pi^2)x_1^2 + (5/\pi)x_1 - 6)^2 + 10(1 - (1/8\pi))\cos(x_1) + 10$
Dixon-Price	UN	30	[−10,10]	$F_{min} = 0$	$f(x) = (1 - x_1)^2 + (1 - x_{10})^2 + \sum_{j=1}^{9}(x_j^2 - x_{j+1})^2$
Griewank	MN	30	[−600,600]	$F_{min} = 0$	$f(x) = \sum_{j=1}^{n} x_j^2/4000 - \prod_{j=1}^{n}\cos(x_j/\sqrt{j}) + 1$
Rastrigin	MS	30	[−5.12,5.12]	$F_{min} = 0$	$f(x) = x_1^2 + 2x_2^2 - 0.3\cos(3\pi x_1) -0.4\cos(4\pi x_2) + 0.7$
Rosenbrock	UN	30	[−30,30]	$F_{min} = 0$	$f(x) = \sum_{j=1}^{n-1}(100(x_j^2 - x_{j+1})^2 + (x_j - 1)^2)$
Schaffer	MN	2	[−100,100]	$F_{min} = 0$	$f(x) = 0.5 + \frac{\sin^2(\sqrt{x^2+y^2}) - 0.5}{[1+0.001\cdot(x^2+y^2)]^2}$
Schwefel	MS	30	[−500,500]	$F_{min} = -12569.5$	$f(x) = \sum_{i=1}^{n}(-x_i\sin(\sqrt{\lvert x_i \rvert})) + \alpha \cdot n$
Sphere	US	30	[−100,100]	$F_{min} = 0$	$f(x) = \sum_{i=1}^{n} x_i^2$