

# Local Search Strategy Embedded ABC and Its Application in Cost Optimization Model of Project Time Schedule

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## ABSTRACT

This article describes how artificial bee colony (ABC) is a promising metaheuristic algorithm, modeled on the intelligent foraging behavior of honey bees. ABC takes its inspiration from natural honey bees. In ABC the colony of bees is generally alienated into three groups namely scout, employed and onlooker bees that participates in getting optimal food sources (solutions). With an edge over similar metaheuristic algorithms in solving optimization problems ABC suffers with bad exploitation (local search) capability, however excels in exploration (global search) capability. In order to balance both the aforesaid capabilities, this article embeds the local search strategy in the basic structure of ABC. The proposed scheme is named as LS-ABC. The efficiency of the proposed scheme has been tested and simulated results are compared with state-of-art algorithms over 12 benchmark functions. Also, LS-ABC has been validated to solve cost optimization model of project time schedule. The simulated results are compared with state-of-art algorithms.

## KEYWORDS

Artificial Bee Colony, ABC, Local Search, Optimization, Metaheuristics, Project Management, Scheduling

## 1. INTRODUCTION

Optimization problem exist in every domain may be Science, Engineering or Management. These optimization problems are generally solved by traditional or non-traditional methods, based on the complexity of the problem. Traditional methods such as gradient search methods require a problem to be continuous and a differentiable whereas non-traditional method hardly require any domain knowledge of the problem. These methods simulate the behavior of natural species such as flock of birds, school of fishes, ants, bees, etc., and inspired by the Darwin theory of ‘survival of the fittest’ (Nizar Banu & Andrews, 2015; Hvattum, 2015; Moghaddam et. al., 2017; Khari & Kumar, 2017; Dey, 2017; Dey & Ashour, 2017; Jagatheesan et al., 2017; Pant et al., 2017). The brief overview of non-traditional methods can be referred from (Rajpurohit et al., 2017). Among these non-traditional methods Artificial Bee Colony (ABC) is recently introduced by Karaboga (Karaboga, 2005). ABC, due to fewer number of control parameters has been widely applied to solve many applications (Sharma & Pant, 2011; 2013; Karaboga et al., 2014; Sharma et al., 2014a, 2014b, 2015; Li et al., 2016; Mao & Duan, 2016; Khandelwal et al., 2016; Sharma & Pant, 2017a, 2017b, Mao et al., 2017; Anuar et al., 2017). But like other non-traditional methods, ABC also suffers with an inherent limitation of poor exploitation capability (Gao et al., 2012). This causes trapping in local optima and results

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in slow convergence rate while dealing with multimodal problems. ABC is good at exploration. In recent past several researchers modified the structure of basic ABC. In this study, both the onlooker phase and the employed phase of ABC have been embedded with local search strategy to overcome the aforementioned limitation of ABC. The proposed strategy uses the information of best individual in the current population to originate new individuals, which assist in exploiting the locality of the best solution in the current population. The proposed variant is named as LS-ABC (Local Search based ABC). The performance of the proposal has been tested over 12 benchmark functions (Sharma & Pant, 2013) and a cost optimization model of project time schedule (Klanšek & Pšunder, 2010).

The paper is structured as follows: Section 2 presents a brief about ABC; Section 3 describes the proposal along with motivation. Problem definitions are discussed in Section 4. Parameter tuning and results are discussed in Section 5. Section 6 concludes the paper with future scope.

## 2. ARTIFICIAL BEE COLONY

Artificial Bee Colony simulates the foraging process of natural honey bees. The bee colony in ABC has been divided into three groups which are named as scout, employed and onlooker bees. Scout bees' initiates searching of food sources randomly, once the food sources are found by scout bees they become employed bees. The employed bees exploit the food sources as well as shares the information about food sources (quality and quantity) to the onlooker bees (bees resting in the hive and waiting for the information from employed bees) by performing a specific dance termed as "*waggle dance*". The ABC algorithm is presented below:

### 2.1. Initialization of Random Food Sources

The food sources (FS) or population of solutions are randomly generated in the search space using following Equation (1):

$$x_{ij} = lb_j + rand(0,1) \times (ub_j - lb_j) \quad (1)$$

where  $i$  represents the  $FS$  and  $j$  denotes the  $j^{th}$  dimension.  $lb$  and  $ub$  are the upper and lower bounds of the search domain.

### 2.2. Employed Bee Process

The search equation involved in this phase and also performs the global search by introducing new food sources  $V_i = (v_{i1}, v_{i2}, \dots, v_{iD})$  corresponding to  $X_i = (x_{i1}, x_{i2}, \dots, x_{iD})$  is discussed below:

$$v_{ij} = x_{ij} + rand(-1,1) \times (x_{ij} - x_{kj}) \quad (2)$$

where  $k$  is randomly chosen index and different from  $i$ . Greedy selection mechanism is performed to select the population to store in a trail vector. The probability of food sources based on the objective function values ( $f_i$ ) are evaluated using Equation (3):

$$P_i = \begin{cases} \frac{1}{(1 + f_i)} & \text{if } f_i \geq 0 \\ 1 + abs(f_i) & \text{if } f_i < 0 \end{cases} \quad (3)$$

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