A State-of-the-Art Review of Artificial Bee Colony in the Optimization of Single and Multiple Criteria

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ABSTRACT

Nowadays computers are used to solve a variety and multitude of complex problems facing in every sphere of peoples’ life. However, many of the problems are intractable in nature exact algorithm might need centuries to manage with formidable challenges. In such cases heuristic or in a broader sense meta-heuristic algorithms that find an approximate solution but have acceptable time and space complexity play indispensable role. In this article, the authors present a state-of-the-art review on meta-heuristic algorithm popularly known as artificial bee colony (ABC) inspired by honey bees. Moreover, the ABC algorithm for solving single and multi-objective optimization problems have been studied. A few potential application areas of ABC are highlighted as an end note of this article.

Keywords: Artificial Bee Colony (ABC), Multi-Objective Optimization, Pareto Optimal Solution, Single Criterion Optimization Problem, Swarm Intelligence

1. INTRODUCTION

In real life, many problems tend to be very obscure / intricate and relate to analysis of big data sets. Even if a deterministic algorithm can be developed its time or space complexity may turn out unacceptable (Garey & Johnson, 1979). However, in reality it is often sufficient to find an approximate or partial solution. Such admission extends the set of techniques to cope with the problem. We discuss one of the heuristic algorithms popularly known as ABC (Karaboga, 2005, Karaboga & Basturk, 2007), which suggest some approximations to the solution of optimization problems. Further, it is realized that many real-world issues are easily stated as optimization problems either single objective or many objectives (Roy, Dehuri & Cho, 2011, Das, Roy, Dehuri & Cho, 2011). The collection of all possible solutions for a given problem can

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be regarded as a search space, and optimization algorithms (e.g., ABC), in their turn, are often referred to as search algorithms. In single objective optimization problems the objective is to find the optimal of all possible solutions that is one that minimizes or maximizes an objective function. A few potential applications of ABC on single objective optimization can be obtained in Karaboga, Gorkemli, Ozturk, and Karaboga (2012).

As stated earlier in numerous engineering optimization problems, the task of obtaining suitable solutions/designs becomes a multi-objective (or multi-criteria) problem. This means it is necessary to look for a solution in the design space that satisfies several objectives in the performance space. Generally, these specifications are conflicting, that is, there is no simultaneous optimal solution for all of them. In this context, the solution is not a single global optimal, instead there is a set of possible solutions where none is best for all objectives. This set of optimal solutions in the design space is called the Pareto set. The region defined by the performances (the value of all objectives) for all Pareto set points is called the Pareto front. The exact determination of the Pareto front is unrealistic for real-world problems, as it is usually an infinite set. Therefore, it is usual to focus on obtaining a discrete approximation. A common step for solving a multi-objective optimization problem is to obtain the discrete approximation of the Pareto front. This is an open research field where numerous techniques have already been developed (Ghosh, Dehuri, and Ghosh 2008, Ehrigott, 2005) and where new techniques are being constantly developed (Coello Coello, Dehuri, & Ghosh, 2009, Roy, Dehuri & Cho, 2011, Das, Roy, Dehuri & Cho, 2011). An alternative, and very active research line, is multi-objective ABC (Hedayatzadeh, Hasanizadeh, Akbari & Ziarati, 2010, Qu & Suganthan, 2011). Over the years, many attempts have been made in developing multi-objective ABC, but we realize that a survey is missing in this direction. Hence, to fulfill the gap, this contribution can be used as a guide for interested users.

Alongside, the basics of swarm intelligence in general with pertinent definitions and concepts are also discussed to ignite young minds.

1.1. Overview of Swarm Intelligence

The optimization algorithms based on heuristic measures can be made depending on the nature of phenomenon simulated by the algorithm (Yang, 2008). In the trend of meta-heuristic approaches, swarm intelligence are attracting a lot of attentions (Lim, Jain, & Dehuri, 2009). The swarm intelligence (SI) algorithm is functioning by the collective behavior of decentralized, and self organized agents. The term swarm is used in a general manner to refer to any restrained collection of interacting agents or individuals. The classical example of swarm is bees swarming around their hive. Swarm intelligence works on two basic principles:

1. Self organization and
2. Stigmergy.

a. Self Organization


- **Structure:** Emerging from a homogeneous startup state, e.g., foraging trails and nest architecture.
- **Multi-Stability:** Coexistence of many stable states, e.g., bees exploits only one of two identical food sources.
- **State Transitions:** With a dramatic change of the system behavior. E.g., termites move from a non-coordinated to a coordinated phase only if their density is higher than a threshold value.
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