African Buffalo Optimization for One Dimensional Bin Packing Problem

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ABSTRACT

African Buffalo Optimization (ABO) is one of the most recent bioinspired metaheuristics based on swarm intelligence. It is inspired by the buffalo’s behavior and lifestyle. ABO Metaheuristic showed its effectiveness for solving several optimization problems. In this contribution, we present an adaptive ABO for solving the NP-hard one dimensional Bin Packing Problem (1BPP). In the proposed algorithm, we used the ABO algorithm in combination with Ranked Order Value method to obtain discrete values and Bin Packing Problem heuristics to incorporate the problem knowledge. The proposed algorithm is used to solve 1210 of 1BPP instances. The obtained results are compared with those found by recent algorithms in the literature. Computational results show the effectiveness of the proposed algorithm and its ability to achieve best and promising solutions.

KEYWORDS

African Buffalo Optimization, Metaheuristic, One Dimensional Bin Packing Problem, Optimization, Swarm Intelligence

1. INTRODUCTION

Metaheuristics are general and applicable methods on wide range of optimization problems. They are able to find good solutions within reasonable running times. The majority of the proposed metaheuristics in the literature are inspired by nature systems like: Simulated Annealing (SA) (Kirkpatrick et al., 1983) that is inspired by a metallurgical process, Genetic Algorithms (GA) (Holland, 1975) that are inspired by the principles of Darwinian evolution and biology, Tabu Search (TS) (Glover, 1986) that draws on the memory of human beings, algorithms based on swarm intelligence such as Particle Swarm Optimization (PSO) algorithm (Kennedy & Eberhart, 1997), Ant Colony Optimization (ACO) (Dorigo, 1992), Bee Colony Algorithm (BCA) (Karaboga, 2005), Cuckoo Search (CS) (Yang & Deb, 2009), Cuckoo Optimization Algorithm (COA) (Rajabioun, 2011), Penguins Search Optimization (PSO) (Gheraibia & Moussaoui, 2013) and African Buffalo Optimization (ABO) (Odili et al., 2015).

Optimization metaheuristics based on swarm intelligence have built a very active trend over the last decade (Asim et al., 2017, 2018; Shah et al., 2018). They are generally inspired by the lifestyle of some species evolving in groups and their collective behavior in solving their problems. These species gather in swarms to build a collective force that allows them to surpass their very limited
individual capacities. African Buffalo Optimization is one of the most recent swarm intelligence-based methods. It is proposed in 2015, by Julius Beneoluchi Odili et al. (2015).

ABO is inspired from the behavior of African buffaloes in the vast African forests and savannahs (Odili et al., 2015). Despite his young age, ABO has attracted the attention of several researchers who have used it to solve several hard optimization problems such as: Traveling Salesman Problem (Odili & Kahar, 2015a), Cannel Allocation Problem (Padmapriya & Maheswari, 2017), Knapsack Problems (Gherboudj, 2018), Budget-Constrained Maximal Covering Problem (Almonacid et al., 2017). The applications of ABO Metaheuristic for optimization problems show its promising effectiveness.

Bin Packing Problem (BPP) is NP-hard combinatorial optimization problems. It has several practical applications in which a set of items should be grouping in a collection of subsets according to some constraints. Bin Packing Problem is solved with several methods which integrate generally the specific BPP heuristics to deal with this hard problem. In this study, our main objective is to solve the one dimensional version of Bin Packing Problem (noted 1BPP) with the new metaheuristic African Buffalo Optimization.

The remainder of this paper is organized as follows: Section 2 presents the BPP. Section 3 presents briefly some heuristics and methods for solving BPP. Section 4 presents the ABO method. The proposed algorithm is described in section 5. The experimental results are presented in section 6 and the conclusion is provided in the seventh section of this paper.

2. BIN PACKING PROBLEM

Bin Packing Problems are combinatorial grouping problems. They can be classified based on their dimension into: one dimensional, two dimensional, three dimensional and multi-dimensional Bin Packing problems. BPP appear in large practical optimization problems in real life and industrial applications including: logistics, manufacturing, wireless communication and engineering (Garey & Johnson, 1979; Fleszar, 2012; Sathe et al., 2009; Dokeroglu & Cosar, 2014). They also occur as main or sub problem in several optimization problems such as Cutting Stock problem (Gilmore & Gomory, 1961, 1963), Scheduling problems (Davidović et al., 2012; Qiao et al., 2010), Loading and Resource Allocation problem (Zezzatti et al., 2012), Sheet Metal Forming Processes (Sathe et al., 2009) and problems of the Cloud Computing Management (Régis & Rezgui, 2011).

Bin Packing Problems consist to pack a set of items into a minimum number of bins. The one dimensional Bin Packing Problem is the base and classic version of Bin Packing Problems. The other versions are a generalization of the one dimensional version and each version has its specific constraints and formulation. Therefore, each version of the Bin Packing Problems can be studied separately because it can be solved with specific methods and heuristics. As a first step in a study on Bin Packing Problems, we are interested in this work by the one dimensional Bin Packing Problem version.

The one dimensional Bin Packing Problem is known to be NP-hard (Coffman et al., 1996). It is defined as the process of packing a set of n items \( \{i_1, i_2, \ldots, i_n\} \) into a minimum number m of empty bins. In 1BPP, each item i has a size \( S(i) > 0 \) and it should be packed in only one bin. The number of bins is assumed to be unlimited. The bins are identical, and they have a fixed capacity \( C > 0 \). The sum of item sizes packed in a given bin must not exceed its capacity.

The 1BPP is formulated in the following way:

\[
\text{Minimize } f(y) = \sum_{j=1}^{m} y_j \tag{1}
\]

subject to constraints:
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