Application of the Bee Swarm Optimization BSO to the Knapsack Problem

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Abstract. Swarm Intelligence is the part of Artificial Intelligence based on study of actions of individuals in various decentralized systems. The optimization algorithms which are inspired from intelligent behavior of honey bees are among the most recently introduced population based techniques. In this paper, a novel hybrid algorithm based in Bees Algorithm and Particle Swarm Optimization is applied to the Knapsack Problem. The Bee Algorithm is a new population-based search algorithm inspired by the natural foraging behavior of honey bees, it performs a kind of exploitative neighborhood search combined with random explorative search to scan the solution, but the results obtained with this algorithm in the Knapsack Problem are not very good. Although the combination of BA and PSO is given by BSO, Bee Swarm Optimization, this algorithm uses the velocity vector and the collective memories of PSO and the search based on the BA and the results are much better.

Keywords: Swarm Optimization, PSO, BA, BSO, Knapsack Problem.

1 Introduction

Evolutionary and meta-heuristic algorithms have been extensively used as search and optimization tools during this decade in several domains from science and engineering to the video game industry, and others.

Many demanding applications that involve the solution of optimization problems of high complexity, a lot of these belonging to a special class of problems called NP-hard have been solved by various methods [8]. Metaheuristic algorithms are now considered among the best tools must to find good solutions with a reasonable investment of resources.

As described by Eberhart and Kennedy [4] Particle Swarm Optimization or *PSO* algorithm is part of the Swarm Intelligence and is a metaheuristics that use the social-psychological metaphor; a population of individuals, referred to as particles, adapts by returning stochastically toward previously successful regions.

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The PSO simulate a society where each individual contributes with his knowledge to the society. These metaheuristics have proved their ability to deal with very complicated optimization and search problems.

The behavior of a single ant, bee, termite or wasp often is too simple, but their collective and social behavior is of paramount significance. The collective and social behavior of living creatures motivated researchers to undertake the study of today what is known as Swarm Intelligence [5]. Two fundamental concepts, self-organization and division of labor, are necessary and sufficient properties to obtain swarm intelligent behavior.

The Bee Algorithm or *BA* [9] is also part of the *Swarm Intelligence* and this mimics the honey bees and who this search their food foraging. This algorithm is based on a random search on the neighborhood for combinatorial and functional optimization.

The *Knapsack Problem* is a classical combinatorial problem [3][14] can be described as follows: “Imagine taking a trip to which you can only carry a backpack that, logically, has a limited capacity. Given a set of items, each with a weight and a value, determine the number of each item to include in a bag so that the total weight is less than a given limit and the total value is as large as possible”, this problem can be considerate as NP-easy problem but some studies show that the Knapsack Problem is an NP-Hard problem [2].

Actually the Knapsack Problem can be modeled by different ways [15] for example multi-dimensional and multiple Knapsack problem [1][13][16], quadratic Knapsack problem [6][12].

In the present paper we introduce the *Bee Swarm Optimization* or *BSO*. This algorithm is a hybrid metaheuristic between the *PSO* and the *BA*. The *BSO* use the better characteristics from both algorithms, the *Social Metaphor* from the *PSO* and the random search in the neighborhood from the *BA*, and give us a better result. The experiments were made on seven types of instances from uncorrelated, to strongly correlated. All these instances probe the algorithm varying the parameters of the profits and the weight. The algorithm was probed with an initial population of random solutions that meet the next conditions: reproducibility, without repetition inside a determinate length chain, statistically independent, fast generation process, and a minimal space inside memory. This pseudorandom number generator helps the algorithm to work better. Another important characteristic is the Confidence Interval of the results.

2 Knapsack Problem

The Knapsack problem [14] is the typical combinatorial problem that has been studied along many years and was proved that it is a NP-Hard problem [11]. The basic problem is the 0-1 Knapsack Problem or Binary Knapsack Problem and it have a search space of 2^n - possible solutions.

The Knapsack Problem can be described as follows: there are objects, each of this objects have a profit and weight, and needs to select those whose sum of their benefits is maximized subject to the sum of the weight of the same objects should not exceed an amount determined. It can be formulated mathematically by