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The Bees Algorithms in Optimization: An Overview

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Abstract :

Metaheuristic algorithms have become powerful tools for modeling and optimization. In this article, we provide an overview of Bee Algorithms and their applications. We will briefly introduce algorithms such as bee algorithms, virtual bee algorithm, artificial bee algorithm, bee mating algorithm, etc. We also briefly the main characteristics of these algorithms and outline some recent applications of these algorithms.

Keywords : Nature-Inspired Algorithm; Bee Algorithm; Metaheuristic Algorithms; Optimization

1. Introduction :

In metaheuristic algorithms, meta- means beyond or higher level. They generally perform better than simple heuristics. The variety of solutions of all metaheuristic algorithms is often realized via randomization. We know that there is

no agreed definition of heuristics and metaheuristics in the literature. Some researchers use heuristics and metaheuristics interchangeably. However, the recent trend tends to name of all stochastic algorithms with randomization and global exploration as metaheuristic. Randomization provides a good way to move away from local search to the search on the global scale. Therefore, almost all metaheuristic algorithms are usually suitable for nonlinear modeling and global optimization. Metaheuristics can be an efficient way to produce acceptable solutions by trial and error to a complex problem in a reasonably practical time. The complexity of the problem of interest makes it impossible to search every possible solution or combination, the aim is to find good feasible solution in an acceptable timescale. There is no guarantee that the best solutions can be found, and we even do not know whether an algorithm will work and why if it does work [13]. The idea is to have an efficient and practical algorithm that will work most the time and is able to produce good quality solutions [1]. Among the found quality solutions, it can be expected that some of them are nearly optimal, though there is no guarantee for such optimality. The main components of any metaheuristic algorithms are: intensification and diversification, or exploitation and exploration [3]. Diversification means to generate diverse solutions so as to explore the search space on the global scale, while intensification means to focus on the search in a local region by exploiting the information that a current good solution is found in this region. This is in combination with the selection of the best solutions [14]. The selection of the best ensures that the solutions will converge to the optimality. On the other hand, the diversification via randomization avoids the solutions being trapped at local optima, while increases the diversity of the solutions. The good combination of these two major components will usually ensure that the global solution is achievable. Metaheuristic algorithms can be classified in many ways. One way is to classify them as: population-based and trajectory-based [15]. On the other hand, Simulated Annealing (SA) uses a single solution which moves through the design space or search space, while artificial neural networks use a different approach [8].

2. Metaheuristic Algorithms :

Human in early life solve their problems by trial and error. The trial and error is actually heuristic and metaheuristics approach. Most of the classical discoveries were done by thinking beyond the limitations or by accident; that is

heuristics. Discovery of penicillin was a heuristic triumph. In fact, our daily learning experience (at least as a child) is dominantly heuristic. Convergence analysis of a few algorithms shows some insight, but in general mathematical analysis of metaheuristic algorithms still has many open questions and still an ongoing active research topic. The notable performance of metaheuristic algorithms often result from that they imitate the best features in nature. Intensification and diversification are two main features of the metaheuristic algorithms [15].

3. Metaheuristic Algorithms in Optimization :

Sometime it is very difficult to find optimal solution to an optimization problem. Such type of optimization problem depends on the choice and the correct use of the right algorithm and an algorithm may depend on the type of problem, the available of algorithms, computational resources, and time constraints. There is no common acceptable guideline for algorithm choice for large-scale, nonlinear, global optimization problems, and in many cases, there is no efficient algorithm. For non deterministic hard optimization problems, polynomial-time hard, or NP-hard, optimization problems, there is no efficient algorithm. Various algorithms may be used for solving optimization problems. The conventional or classic algorithms are mostly deterministic. As an instance, the simplex method in linear programming is deterministic. Some other deterministic optimization algorithms, such as Newton-Raphson algorithm, use the gradient information and are called gradient-based algorithms. Non-gradient-based, or gradient-free/derivative-free, algorithms only use the function values, not any derivative [14]. Heuristic and Metaheuristic are the main types of the stochastic algorithms. The difference between Heuristic and metaheuristic algorithms is negligible. Heuristic means to find or to discover by trial and error. Metaheuristic optimization algorithms are often inspired from nature. According to the source of inspiration of the metaheuristic algorithms they can be classified into different categories. Our prime category is the biology-inspired algorithms which generally use biological evolution or collective behavior of animals or both.

3.1 Swarm-Intelligence-Based Algorithms :

Swarm intelligence based algorithms use the collective behavior of animals such as birds, insects or fishes. There are many optimization problems based on

swarm-intelligence-based algorithms, such as particle swarm optimization, ant colony optimization, bees algorithm, firefly algorithm, cuckoo search, bat algorithm charged system search, Krill herd, etc. In this article, we introduce briefly bees algorithms and its progressive development.

3.1.1 Virtual Bee Algorithms :

The mimic behavior of bees was first introduced by Yang X.S. in 2005 [16]. He suggests that the bees interact when they find some target nectar corresponding to the encoded values of the function. The solution for the optimization problem can be obtained from the intensity of bee interactions. The simulations of the optimization of De Jongs test function and Keanes multi-peaked bumpy function show that the one agent VBA is usually as effective as genetic algorithms and multiagent implementation optimizes more efficiently than conventional algorithms due to the parallelism of the multiple agents [16]. The same year, Karaboga [6], introduced the idea based bee algorithm for numerical optimization. The minimal model of forage selection that leads to the emergence of collective intelligence of honey bee swarms consists of three essential components: food sources, employed foragers and unemployed foragers and the model defines two leading modes of the behaviour: the recruitment to a nectar source and the abandonment of a source. At last he concluded that the proposed algorithm can be used for solving unimodal and multi-modal numerical optimization problems.

3.1.2 Bee Algorithms for Complex Optimization Problems :

In 2006, D.T. Pham et al. [10] introduce a new population-based search algorithm called the Bees Algorithm (BA) for complex optimization problems. The algorithm mimics the food foraging behaviour of swarms of honey bees. In its basic version, the algorithm performs a kind of neighborhood search combined with random search and can be used for both combinatorial optimization and functional optimization. This paper focuses on the latter. Following a description of the algorithm, the paper gives the results obtained for a number of benchmark problems demonstrating the efficiency and robustness of the new algorithm [10].

3.1.3 Honey Bee Mating Optimization Algorithms :

This concept was first introduced by Afshar et al. [2] in 2007. The Honey

Bees Mating Optimization is based on the mating behaviour of honey bees for a financial classification problem. Financial decisions are often based on classification models which are used to assign a set of observations into predefined groups. One important step towards the development of accurate financial classification models involves the selection of the appropriate independent variables (features) which are relevant for the problem at hand. The proposed method uses for the feature selection step, the Honey Bees Mating Optimization algorithm while for the classification step, Nearest Neighbor based classifiers are used. The performance of the method is tested in a financial classification task involving credit risk assessment. The results of the proposed method are better then others method [2].

3.1.4 Artificial Bee Colony Algorithms :

This concept was first introduced by Dervis Karaboga and Bahriye Basturk in their article [5]. They proposed that Artificial Bee Colony (ABC) Algorithm is an optimization algorithm based on the intelligent behaviour of honey bee swarm. In this article, they use ABC algorithm for optimizing multivariable functions and apply the results produced by ABC with results of Genetic Algorithm (GA), Particle Swarm Algorithm (PSO) and Particle Swarm Inspired Evolutionary Algorithm (PS-EA). Their results showed that ABC performs better then the other algorithms.

3.1.5 Enhance Artificial Bee Colony Optimization Algorithms :

An enhanced Artificial Bee Colony (ABC) optimization algorithm or the Interactive Artificial Bee Colony (IABC) optimization is proposed by P.W. TSai1, J.S. Pan1, B.Y. Liao1, and S.C. Chu. in their article [11], for numerical optimization problems. In this paper, they say that the onlooker bee is designed to move straightly to the picked coordinate indicated by the employed bee and evaluates the fitness values near it in the original Artificial Bee Colony algorithm in order to reduce the computational complexity. Hence, the exploration capacity of the ABC is constrained in a zone. Based on the framework of the ABC, the IABC introduces the concept of universal gravitation into the consideration of the affection between employed bees and the onlooker bees. By assigning different values of the control parameter, the universal gravitation should be involved for the IABC when there are various quantities of employed bees and the single onlooker bee. Therefore, the exploration ability

is redeemed about on average in the IABC. They also proposed five benchmark functions which are simulated in the experiments in order to compare the accuracy/ quality of the IABC, the ABC and the PSO. The experimental results of the proposed IABC hold the superiority in accuracy to other methods.

3.1.6 Directed Bee Colony Optimization Algorithm :

This concept was introduced by M. Rajeswari, J. Amudhavel, Sujatha Pothula, and P. Dhavachelvan in their article [9]. The Nurse Rostering Problem is an NP-hard combinatorial optimization, scheduling problem for assigning a set of nurses to shifts per day by considering both hard and soft constraints. They suggest that a novel metaheuristic technique is required for solving Nurse Rostering Problem (NRP). They propose a metaheuristic technique called Directed Bee Colony Optimization Algorithm using the Modified Nelder-Mead Method for solving the NRP. To solve the NRP, they used a multiobjective mathematical programming model and proposed a methodology for the adaptation of a Multiobjective Directed Bee Colony Optimization (MODBCO). MODBCO is used successfully for solving the multiobjective problem of optimizing the scheduling problems. This MODBCO is an integration of deterministic local search, multiagent particle system environment, and honey bee decision-making process. The performance of the algorithm is assessed using the standard data set INRC2010, and it reflects many real-world cases which vary in size and complexity. The experimental analysis uses statistical tools to show the uniqueness of the algorithm on assessment criteria.

3.1.7 Honey Bees Inspired Optimization Method :

In 2013, Baris Yuce, Michael S. Packianather, Ernesto Mastrocinque , Duc Truong Pham and Alfredo Lambiase introduced this method [4]. Optimization algorithms are search methods where the goal is to find an optimal solution to a problem, in order to satisfy one or more objective functions, possibly subject to a set of constraints. Studies of social animals and social insects have resulted in a number of computational models of swarm intelligence. Within these swarms their collective behavior is usually very complex. The collective behavior of a swarm of social organisms emerges from the behaviors of the individuals of that swarm. They developed computational optimization methods based on biology such as Genetic Algorithms, Particle Swarm Optimization, and Ant Colony. The aim of this

paper is to describe an optimization algorithm called the Bees Algorithm, inspired from the natural foraging behavior of honey bees, to find the optimal solution. They showed that the algorithm performs both an exploitative neighborhood search combined with random explorative search. In this paper, after an explanation of the natural foraging behavior of honey bees, the basic Bees Algorithm and its improved versions are described and are implemented in order to optimize several benchmark functions, and the results are compared with those obtained with different optimization algorithms. The results show that the Bees Algorithm offering some advantage over other optimization methods according to the nature of the problem.

3.1.8 Improved Bees Algorithm for Real Parameter Optimization :

This article is introduced by Wasim A. Hussein et al. [12] in 2015. They divided the Bees Algorithm (BA) into four parts: the parameter tuning part, the initialization part, the local search part, and the global search part. Then they proposed a new local search algorithm for the Levy looping flights on Patch-Levy-based Initialization Algorithm (PLIA-BA). Moreover, the mechanism of the global search has been enhanced to be closer to nature and based on the Patch-Levy model adopted in the Initialization Algorithm (PLIA). The improvements in local and global search parts are incorporated into PLIA-BA to advise a new version of BA that is called Patch-Levy-based Bees Algorithm (PLBA). We investigate the performance of the proposed PLBA on a set of challenging benchmark functions. The results of the experiments indicate that PLBA significantly outperforms the other BA variants, including PLIA-BA and can produce comparable results with other state-of-the-art algorithms [12].

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