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RELEVANCE OF ARTIFICIAL BEE COLONY ALGORITHM OVER OTHER SWARM INTELLIGENCE ALGORITHMS

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***Abstract-* A new population-based search algorithm called the Bees Algorithm (BA) is presented in this paper. The algorithm mimics the food foraging behavior of swarms of honey bees. This algorithm performs a kind of neighborhood search combined with random search and can be used for both combinatorial optimization and functional optimization and with good numerical optimization results. ABC is a meta-heuristic optimization technique inspired by the intelligent foraging behavior of honeybee swarms. This paper demonstrates the efficiency and robustness of the ABC algorithm to solve MDVRP (Multiple depot vehicle routing problems).**

Keywords- *Swarm intelligence, ant colony optimization, Genetic Algorithm, Particle Swarm optimization, Artificial Bee Colony optimization.*

1. INTRODUCTION

Optimization algorithms based on swarm intelligence, known as meta-heuristic algorithms, gained popularity in solving complex and high dimensional optimization problems years ago. Since most of the meta-heuristic methods are independent of the initial solutions and are derivative-free, they overcome the main limitations of deterministic or conventional optimization methods, i.e., getting trapped in local extreme and divergence situations, respectively.

Optimization problems can be classified into constrained and unconstrained types. The former includes most of the practical and real-world applications. Thus, the constraints of an optimization problem are commonly solved via independent (constraint-handling) techniques. The effectiveness varies from one technique to another and, also, with different algorithms. Moreover, the superiority of current and future meta-heuristic algorithms can be determined through solving benchmark optimization functions where statistical records emphasize their effectiveness.

Section 2 reviews related work in the area of intelligent optimization. Section 3 describes the foraging behavior of natural bees and the core ideas of the proposed Bees Algorithm. Section 4 detail the betterness of ABC related to other optimization techniques.

2. SWARM OPTIMIZATION

Swarm-based optimization algorithms (SOAs) mimic nature's methods to drive a search towards the optimal solution. A key difference between SOAs and direct search algorithms such as hill climbing and random walk is that SOAs use a population of solutions instead of a single solution [7]. As a population of solutions is processed in iteration, the outcome is also a population of solutions. If an optimization problem has a single optimum, SOA population members can be expected to converge to that optimum solution. However, if an optimization problem has multiple optimal solutions, an SOA can be used to capture them in its final population. SOAs include the Ant Colony

Optimisation (ACO) algorithm, the Genetic Algorithm (GA) and the Particle Swarm Optimization (PSO) algorithm.

Swarm intelligence, as a scientific discipline including research fields such as swarm optimization or distributed control in collective robotics, was born from biological insights about the incredible abilities of social insects to solve their everyday-life problems [7]. Their colonies ranging from a few animals to millions of individuals, display fascinating behaviors that combine efficiency with both flexibility and robustness. Surprisingly, the complexity of these collective behaviors and structures does not reflect at all the relative simplicity of the individual behaviors of an insect. Of course, insects are elaborated "machines", with the ability to modulate their behavior on the basis of the processing of many sensory inputs.

The SI is illustrated with well known examples and introduces the major concepts underlying the swarm intelligence research field: decentralization, stigmergy, self-organization, emergence, positive and negative feedbacks, fluctuations, bifurcations. It also highlights the nature of the relation between the behavior of the individual and the behavior of the group. Common to all population-based search methods is a strategy that generates variations of the solution being sought. Some search methods use a greedy criterion to decide which generated solution to retain. Such a criterion would mean accepting a new solution if and only if it increases the value of the objective function (assuming the given optimization problem is one of optimization).

2.1 ACO (Ant Colony Optimization)

A very successful non-greedy population-based algorithm is the ACO algorithm [1] which emulates the behavior of real ants. Ants are capable of finding the shortest path from the food source to their nest using a chemical substance called pheromone to guide their search. The pheromone is deposited on the ground as the ants move and the probability that a passing stray ant will follow this trail depends on the quantity of pheromone laid. ACO was first used for functional optimization by Bilchev and further attempts were reported in.

2.2 GA (Genetic Algorithm)

The Genetic Algorithm is based on natural selection and genetic recombination. The algorithm works by choosing solutions from the current population and then applying genetic operators – such as mutation and crossover – to create a new population. The algorithm efficiently exploits historical information to speculate on new search areas with improved performance. When applied to optimization problems, the GA has the advantage of performing global search. The GA may be hybridized with domain-dependent heuristics for improved results. For example, Mathuret al describes a hybrid of the ACO algorithm and the GA for continuous function optimization.

2.3 PSO (Particle Swarm Optimization)

The PSO method is a population-based method, [8] where the population is referred to as a *swarm*. The swarm consists of a number of individuals called *particles*. Each particle i in the swarm holds the following information: (i) the current position x_i, which represents a solution to the problem, (ii) the current velocity v_i, (iii) the best position, the one associated with the best objective function value the particle has achieved so far $pbest_i$, where this objective function value is calculated using a function *f(.)* that evaluates the desirability of a solution, and (iv) the neighborhood best position, the one associated with the best objective function value found in the particle's neighborhood $nbest_i$. The choice of $nbest_i$ depends on the neighborhood topology adopted by the swarm, different neighborhood topologies have been studied in this.

3. ARTIFICIAL BEE COLONY ALGORITHM

The Artificial Bee Colony (ABC) Algorithm [5] is a meta-heuristic algorithm for numerical optimization. Meta-heuristics are high-level strategies for exploring search spaces. Many meta-heuristic algorithms, inspired from nature, are efficient in solving numerical optimization problems. ABC algorithm is motivated by the intelligent foraging behavior of honey bees. The ABC algorithm was first proposed by Karaboga in 2005 for unconstrained optimization problems. Subsequently, the algorithm has been developed by Karaboga and Basturk and extended to constrained optimization problems. Improvements to the performance of the algorithm and a hybrid version of the algorithm have been also been proposed.

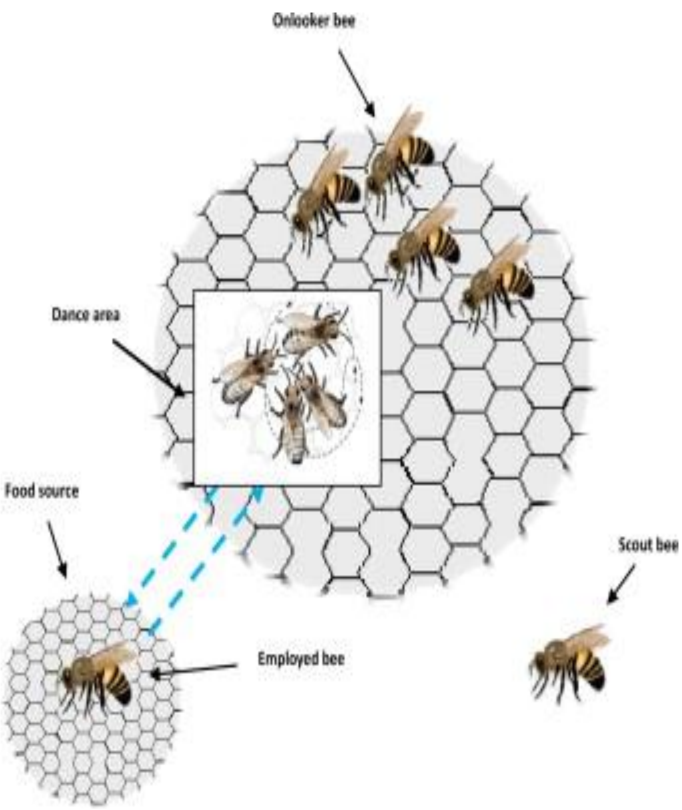

Figure 1: A Typical Bee Colony Model

The artificial bee colony includes three kinds of bees considering the division of labor: employed bees, onlooker bees and scout bees. Each employed bee works on only one food source. An employed bee keeps a food source in her mind when she leaves from the hive and she shares the information about her food source with onlookers on dance area. Onlookers select a food source by watching the dances of the employed bees and try to improve this source. If a food source is abandoned, its employed bee becomes a scout to explore new food sources randomly.

Basic steps of the ABC algorithm are given below:

- Initialize

REPEAT

Step 1: Employed bees phase--send the employed bees to their food sources and determine their nectar amounts.

Step 2: Onlooker bees phase--send onlookers to the food sources depending on their nectar amounts and determine their nectar amounts.

Step 3: Scout bees phase-- send scouts to search new food sources that are replaced with abandoned ones.

Step 4: Memorize the best food source found so far.

UNTIL (termination criteria is satisfied)

4. APPLICATIONS OF ARTIFICIAL BEE COLONY ALGORITHM

Although the ABC algorithm was only recently introduced, the trend of published papers utilizing this algorithm is growing rapidly. Furthermore, the performance of the ABC algorithm, and the results and quality of the solutions, outperformed or matched those obtained using other well-known optimization algorithms.

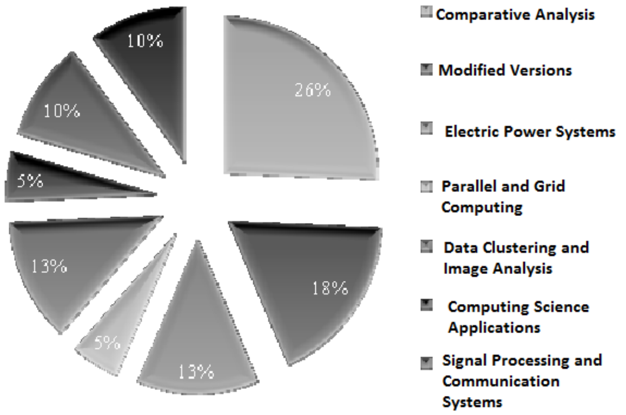

Figure 2: Division of published ABC's papers due to different applications

A. Comparative Analysis

The Sudoku puzzle was solved in [4] via the ABC algorithm. The puzzle is considered a logic-based problem with three constraints. The authors considered three types (easy, medium and hard) of Sudoku puzzles to demonstrate the efficiency of their proposed method. The offered method outperformed other GA-based Sudoku solutions.

B. Modified Versions

A modified version of the ABC algorithm was proposed [4]. The main difference was that once a solution did not improve for a specified number of trials, the whole algorithm was terminated. Subsequently, the employed bees became scouts and explored new solutions randomly. The neighboring searches were always dominated by the best solution associated with employed and onlooker bees. The authors considered 10 benchmark optimization functions and 10 optimized parameters.

C. Electric Power Systems

The Static Economic Dispatch (SED) problem was solved in using the ABC algorithm. The objective was to minimize the total system fuel cost subject to operational equality and inequality constraints. Three test systems were used to evaluate the performance of the algorithm. In addition, the results of the ABC algorithm were compared with deterministic (lambda) technique and various types of PSO and GA algorithms. The results obtained using the ABC algorithm outperformed or matched most of those competing methods.

D. Various Applications

The authors used the ABC algorithm to enhance the equilibrium of plasma in nuclear fusion devices. In other words, the objective function was to minimize the average velocity of the particles. The authors also modified the original ABC algorithm by integrating two levels of employed (elites and workers) and scout (rovers and cubs) bees. Narasimhan in proposed a parallel ABC algorithm to solve numerical optimization functions. First, the colony of bees was distributed equally at each designated processor. Then, solutions obtained from each processor were recorded in a local memory. After that, a global-shared memory retained the improved solutions that attained from each processor.

Comparison of ABC with ACO

The Bees Algorithm needed half of the number of function evaluations compared with GA and one third of that required for ANTS. The eighth test function was a ten-dimensional function. The Bees Algorithm could reach the optimum 10 times faster than GA and 25 times faster than ANTS and its success rate was 100% [1].

Comparison of ABC with GA

The first test function was De Jong's, for which the Bees Algorithm could find the optimum 120 times faster than ANTS and 207 times faster than GA, with a success rate of 100%. The second function was Goldstein and Price's, for which the Bees Algorithm reached the optimum almost 5 times faster than ANTS and GA, again with 100% success. With Branin's function, there was a 15% improvement compared with ANTS and 77% improvement compared with GA, also with 100% success [1].

Comparison of ABC with PSO

The ABC algorithm is a swarm-based algorithm good at solving uni modal and multimodal numerical optimization problems. It is very simple and flexible when compared to the other Swarm Based algorithms such as Particle Swarm Optimization (PSO). It does not require external parameters like mutation and crossover rates, which are hard to determine in prior. The algorithm combines local search methods with global search methods and tries to attain a balance between exploration and exploitation. Researchers have come up with several real-world applications for the ABC algorithm [5].

5. CONCLUSION

This paper has presented an optimization Algorithm ABC. Experimental results on multi-modal functions in n-dimensions show that the proposed algorithm has remarkable robustness, producing a 100% success rate in all cases. The algorithm generally outperformed other techniques that were compared with it in terms of speed of optimization and accuracy of the results obtained. ABC can be used to solve many vehicle routing problems including TSP and many more. Artificial Bee Colony (ABC) Algorithm was implemented which gives better results compared to implementation of Rule Based Algorithm on the system. In the investigations it was found that, the ABC Algorithm of machine learning technique gives a better solutions compared with general Rule Based Algorithm. The algorithm used in the present system can be treated as quite effective; in most of the cases it finds a solution which represents a good approximation to the optimal one. As a future work, the algorithm will be applied on more complex test problems like to solve MDVRP (Multiple Depot Vehicle Routing Problems).

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