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The Applications Survey on Bee Colony Optimization

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***Abstract*- Swarm Intelligence is the most studied area by several researchers it is the part of AI based on the study of actions of individuals in various decentralized system. The BCO metaheuristics has been introduced fairly recently as a new direction in the field of Swarm Intelligence. Artificial Bee represents agents which collaboratively solve complex combinatorial optimization problem. It was introduced in 2005 and has been applied to solve different optimization problems in various areas. BCO is a benchmark system which shows the team work and applied in various optimization problem.**

***Keywords*—Swarm Intelligence (SI), Bee Colony Optimization (BCO), Artificial Bee Colony (ABC).**

I. INTRODUCTION

Nature-Inspired Algorithms are the most studied research area by various computational researchers and its inspired by the various variety of biological and natural processes. The popularity of the Nature-Inspired Algorithms is mainly initiated by the ability of biological systems to efficiently adjust to frequently changeable environment. Evolutionary Computation, Neural Networks, Bee Colony, Ant Colony Optimization, Particle Swarm Optimization, Artificial Immune Systems, and Genetic Algorithm, are the algorithms and concepts that were inspired by nature.

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. The roots of swarm intelligence are deeply embedded in the biological study of self-organized behaviours in social insects. SI is the name given to the mechanism or system where in a group of workers/particles/agents work in collaboration with each other to find optimal solution for the problem in hand. Various examples of SI groups are bird flocks, bee colony, ant colony, particle swarm, cockroaches, fishes, etc. [1] SI systems have strong features like group defines as is in bee colony, labour division as in ant colony, synchronization as in flying birds' flock, collective clustering and sorting, cooperative working etc. In SI the agents form or build a local solution, on the basis of factors/conditions in hand. Based on the local solution, the global solution is developed which then gradually optimizes or channelizes to an optimal solution. So, SI is a bottom-up type of problem solving technique. [1]

In this paper a survey on the areas of applicability of bee colony system have been presented. In this survey work nearly 10 papers on the ground of bee algorithm used.

Organization of this paper is as follows. In Sec. 2 brief description of bee's life in nature for understanding the artificial scenario of bee's system. In Sec.3 discuss the application area of bee system. In Sec. 4 discuss application in tabular form of studied paper. In Sec. 5 conclude the whole work.

II. BEE COLONY

The BCO is inspired by the bee's behaviour in nature. The basic idea behind the BCO is to create multi agent system (colony of artificial bee) capable to solve different combinatorial optimization problem. The artificial bee colony behaves partially alike, and partially differently from bee colonies in nature. The bee system is a standard example of organized team work, well coordinated interaction, coordination, labour division, simultaneous task performance, Specialized individuals, and well-knit communication. [2] In a typical bee colony there are different types of bees. There is a queen bee, many male drone bees and thousands of worker bees. [2]

Types of bees: [2]

1. The Queen's responsibility is of laying eggs so that new colonies can be formed.
2. The Drones are males of the hive and are responsible to mate with the Queen. This is their sole role in the hive. They are discarded from the colony during their down fall.
3. The worker bees are the females of the hive. They are the main building blocks of the hive. They build the honey bee comb, clean it, maintain it, guard it, feed the queen and drones. Apart these side responsibilities the main job of a worker bee is to search and collect rich food. There are two types of worker bees namely scout bees and forager bees. Both of them are collectively responsible for the collection of food but they play different roles.

What does Scout do? [2]

1. The Scout bees fly around and search for food sources available randomly.
2. They return back to the hive after they exhaust their energy and distance limits.
3. Upon returning to the hive they share their exploration experience and a lot of important information with the forager bees.
4. The scouts tell the foragers about the location of rich food sources which comprises of the direction (angle) of the food source from the hive w.r.t. sun and distance from hive. This is done using a dance called "waggle

dance" which is in the figure of digit "8". It also indicates the quality of food.

What does Forager do? [2]
1. The forager bees closely observe the scout bee in order to learn the directions and information given by scout. It then goes to collect food.

Artificial Bee Colony (ABC) was introduced by Karaboga in 2005. It was developed to solve real parameter optimization problem. In ABC the BCO's foraging behaviour is simulated.
The ABC differs from a real BCO since in ABC we use only scouts and foragers in equal proportion as initial population.

The main steps of ABC are:
1. Initialization of food sources.
2. Scouts perform exploration of available food sources randomly until stopping criteria is met.
3. Each Forager exploits the respective scout's food sources until stopping criteria is met.
4. Forager chooses the best food source as per quality.

III. APPLICATION AREA

1. Travelling Salesman Problem (TSP)

TSP is probably the most widely studied combinatorial optimization and it is a benchmark problem which is solved by almost all the latest researching algorithm. The proposed BCO algorithm with local search for TSP in [3] construct algorithmically based on collective intelligence of bee's food searching activities. The proposed algorithm is combined with 2-opt heuristic to generate more promising result and also implemented in JAVA and also the detail analysis is done for compare and show effectiveness over other approaches with the help of the set of benchmark problem.

2. Job Shop Scheduling (JSS)

In this research work [4] BCO is proposed for job shop scheduling problem. Job shop scheduling is a very essential procedure for the manufacturing business as it improves machine utilization as well as reduces cycle-time. It is a NP hard problem. In this research work the authors have proposed BCO algorithm through mapping the food foraging behaviour of honey bees to locate solution. They have also compared the result with the other exsisting algorithm like ACO and Tabu search.

3. MANET- Routing Protocol

A Bee-inspired routing protocol for Mobile Adhoc network has been presented in this research work [5]. This algorithm is designed to provide routing solutions inspired by the foraging principles of bees. The algorithm developed here is a reactive source routing algorithm which consumes less energy as compared to conventional mobile adhoc routing algorithms. In this research work Bee-Adhoc algorithm is use to route the mobile adhoc network. The Bee-Adhoc algorithm was identified as an algorithm with major savings in energy of consumption packets. It was also recognized to be a simpler and easier algorithm to execute.

4. Solving Sudoku Puzzles

A Sudoku is a logical 2D array in row, column, and diagonal without being repeated. In this paper [6] a BCO algorithm has been developed to solve Sudoku puzzles which are NP-hard problems .The algorithm mimic the method by which bees forage food. The obtained results is used to solve Sudoku puzzles more efficiently and successfully.

5. Numerical Optimization

These algorithms have been developed for unimodal and multimodal problems. In this research work [7] an Improved Bee Colony Optimization algorithm, Artificial Bee Colony algorithm and Harmony search algorithm and Bee Algorithm are presented. All the above four experiments have been discussed w.r.t to numerical optimization concept in detail. All the algorithms are designed for unimodal (Sphere, Rosenbrock) and multimodal (Griewank,Rastrigin, Ackley),all the given above algorithm have been designed with five test functions with minimum function value of zero. The result of their work is ABC algorithm is more superior then the other three discussed algorithm.

6. Engineering Optimization

In this work [8] VBA algorithm is presented for engineering optimization problem. The shortcoming of multilevel optimization compared to biology-inspired algorithm has been compared. This has been developed for two variables. It has also been shown that 1 agent VBA, 2 agents VBA and multi agent VBA are all efficient with genetic algorithms when compared to conventional algorithms.

7. Application to Generalized Assignment Problem

In this research work [9] the nature inspired metaheuristic algorithm called ABC algorithm to solve the NP-hard generalized assignment problem is used. In Generalized Assignment Problem a set of assignments have to be assigned to a set of agents with minimum cost. The agents have limited ability. Every agent gets single task. An algorithm using ABC has been designed here. The algorithm has been implemented in C#. The algorithm has been tested for problems comprising of 5 agents-15 tasks to 10 agents-60 tasks.

8. Advisory Systems

This paper [10] deals with the development of garlic expert systems, designed using one of the evolutionary algorithms, to advice the farmers in villages through online. An expert system is a computer program that simulates the judgments and behavior of a human or an organization that has expert knowledge and experience in a particular field. This system contains pre-written instructions and experiences and a set of rules and protocols to advice any scenario. The system here has been implemented in JSP for front end and MYSQL for backend.

9. Numerical Assignment Problem

An Interactive ABC (IABC) optimization algorithm for numerical optimization problem has been projected in this

work. The algorithm maps the forager bee's path development mechanism to choose new coordinates. The forager bee is directed by scout bee which evaluates the fitness values of all possible neighboring coordinates. The proposed algorithm in [11] has been analyzed using 5 benchmark functions to compare the efficiency/quality of IABC over ABC and PSO. The results got from the simulations indicate that the IABC performs better than the original ABC and the PSO by introducing the essence of the universal gravitation into the movement of the onlooker bees and it can be efficiently applied to solve the combinational optimization problems.

10. Developing Optimization Algorithm

In this paper [12] introduced a new algorithm which is Artificial Bee Colony optimization algorithm that are inspired by bee colonies and has been developed for optimization algorithm. This ABC exploits the working of scouts and forager's food foraging behavior to design the algorithm. The proposed algorithm assumes that the bee has short as well as long term memory. They have defined food taboo table and job sheet table to maintain the working of ABC algorithm. The author' suggested that the proposed algorithm can be applied to many combinatorial optimization problems, dynamic real variable problems, stochastic problems etc.

IV. SUMMARIZATION OF APPLICATION

Sr.No.	Algorithm	Application Discussed	Description of work	Tested Problem	Comparison with similar algorithm
1.	BCO	Travelling Salesman Problem	Collective intelligence of bee's food forging behavior and 2-opt heuristic	Yes	Yes
2.	BCO	Job Shop Scheduling	Maps the Food foraging behavior of honey bee	Yes	Yes
3.	Bee-Adhoc Algorithm	MANET Routing Protocol	Simpler and easier, Remarkable savings in energy consumption	Na	No
4.	BCO	Solving Sudoku Puzzles	Food foraging behavior has been mapped	NA	No
5.	BCO	Numerical Optimization	designed with five test functions	NA	Yes
6.	Virtual Bee algorithm (VBA)	Engineering Optimization Problem	one agent VBA, 2 agents VBA and multi agent VBA	NA	Yes
7.	ABC	Generalized Assignment Problem	5 agents-15 tasks to 10 agents-60 tasks.	Yes	Yes
8.	ABC	Advisory System	expert domain based knowledge	NA	No
9.	Interactive ABC (IABC)	Numerical Assignment Problem	maps the forager bee's path development mechanism to pick new coordinates	5 Benchmark Problem	Yes
10	ABC	Developing Optimization Algorithm	1. exploits the working of scouts and forager's food foraging	No	No

V. CONCLUSION

This paper based on the literature survey on the nature inspired algorithm have been presented. In this survey study Bee Colony system have been deeply studied and explain among number of nature inspired algorithm. The study based on the different area of application of BCO algorithm in different domain. It has been found that BCO is well suited for NP-hard problems like Advisory problem, job shop scheduling problem, combinatorial problem etc. In this study the application have been discussed briefly and summarized into a summary table. Algorithm, application, description, and comparison is done in the summary table.

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