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Comparative Study of Two Natural Phenomena Based Optimization Techniques

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Abstract— Optimization technique is used to obtain the best fit solution. Ant Colony Optimization and Bee Colony Optimization both are the natural inspired phenomena which are based on swarm intelligence. These are the multi agent approaches for solving complex problems and provide optimal results. In this paper, we present the comparison between two optimization techniques or approaches, their basic ideas, advantages, disadvantages and their applications.

Index Terms— Ant Colony Optimization, Bee Colony Optimization, Optimization, Swarm Intelligence, Metaheuristic techniques, premature convergence,pheromone liquid.

1 INTRODUCTION

Software is one of the ways to solve problems in many different ways. To solve problems need, understanding the nature of a problem and use software to implement solution if possible and appropriate. In computer science many researchers tried to solve complex problems to get feasible results. Feasible solutions are those which give all the possible results. Optimization results are those which give the best results. Optimization problem is the problem of finding best result from all the feasible results. Many optimization techniques are inspired from natural phenomenon like bee colony optimization, ant colony optimization etc. These techniques are based on Swarm Intelligence. The term Swarm Intelligence is a part of artificial intelligence which is based upon the various decentralized systems. The bee colony optimization approach is “bottom- up” approach which is used to solve complex combinatorial optimization problems [3] to get optimal solutions. Ant Colony Optimization is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs [9]. In this paper optimization techniques have been discussed in the succeeding section.

2 BEE COLONY OPTIMIZATION

A Bee colony optimization is a multi –agent approach based on Swarm intelligence. It is a metaheuritisic technique which is used to solve combinatorial problems and to find out computational results. It is a memory based searching. A BCO optimization is a technique which is used to find out optimal solution or we can say that to find out the best path. Swarm intelligence is an artificial intelligence which is based upon the decentralized and self organizing systems. It is a natural inspired phenomenon. There are different types of bees available in the natural phenomenon.

These bees are Queen Bee which is only one in number, drone male bees which mate with queen bee and worker bees which go outside in the search of food. Worker bees which are thousands in number further divided into two parts: 1) Scout Bee 2) Forager Bee. Scout bees go outside in search of food from source to destination randomly. When these bees are out of energy, they come back to hive and perform waggle dance to communicate with the forager bees. Waggle dance is in the shape of digit 8.It conveys information of location of the food, quality of the food, and distance from hive to food source with respect to sun. This mechanism repeats again and again. So, scout bee is used to explore the path called path exploring or path constructing. Forager bee follows the steps of the scout bees and follows the same path to reach the destination and called path exploiting and path restricting. A BCO algorithm can be used to find maximum fault in minimum execution time and to cover maximum code in minimum execution of time.

Path testing is used at each path to find out best path or for the selection of final path. In BCO algorithm, scout bee construct path and generate PSB table and forager bee follow scout bee and restrict path by exploit scout bee path i.e. PSB table is used as inputs. PFB table is generated by Forager bee and at last forager bee are used to select the final path by covering maximum faults in minimum execution of time. [1] BCO represents algorithm which is applied in various optimization techniques in engineering. Waggle dance is performed in bee hive to communicate with forager bees. By learning from scout bees, forager bees follow same path of scout bees to reach to the food source. A Bee Colony Optimization algorithm is a global optimizer which has low risk of premature convergence and has effective searching process with high complexity.

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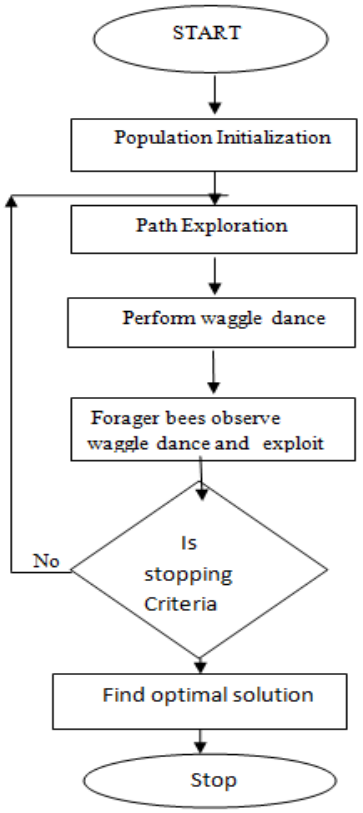

Fig 1: Representing Flow Chart of BCO

Advantages of BCO [2][3]
BCO used very few controlled parameters and easy to implement.

1. In BCO, Bees return to home through direct route instead of back tracking their original route.
2. BCO algorithm can be easily scalable as it requires less computation time to complete task.
3. BCO algorithm is strong robustness, fast convergence and high flexible which allows adjustments and it represent specific knowledge of the problem by observing nature.
4. BCO algorithm can be used for solving multidimensional and multimodal optimization problems.
5. BCO algorithm is efficient when finding and collecting food, as it takes less number of steps.
6. It has ability to explore local solutions.
7. It is time saving process by structuring favourable parallel processing algorithm.

Disadvantages of BCO [2]
BCO algorithm is less adaptive than other algorithms of optimization.

1. To improve performance it requires new fitness tests with new parameters.
2. It requires high number of objective function evaluations.
3. It is slow process to evaluate accurate solutions.
4. Lack of use of secondary information about the problem.
5. It slows down in sequential processing.
6. Deterministic methods have higher accuracy in finding solutions than BCO when it does not get stuck in local minima.
7. There is a chance of losing relevant information on the behavior of the function to be optimized.
8. Pre knowledge of various factors are required like distance from hive, direction etc.
9. It requires deep knowledge of mathematical operators to solve complex problems and obtain feasible results.

Applications of BCO [4]
BCO is used in mechanical engineering design optimization problems.

1. It is used in neural network to train neural network for face reorganization.
2. It is used to solve travelling salesman problem to find out optimal path.
3. It is used to solve ride matching problem.
4. It is also used in networking field in the case of routing and wavelength assignment in all optimal networks.
5. It is also used in electrical engineering in an automatic voltage regulator.
6. It is used in routing in wireless sensor network.
7. It is also used in generation of pair-wise test sets.
8. It is used in image analysis and computer vision.

3 ANT COLONY OPTIMIZATION

Ant colony optimization (ACO) is also a metaheuristic technique which is used to solve combinatorial optimization problems so as to find out the shortest path. It is a Probabilistic technique which used previous solution to find out the best results. To communicate with each other ant use antennas and pheromone liquid. ACO has been inspired from natural ants system, their behavior, team coordination work and synchronization for the searching of optimal solution and it also maintains array list to maintain previous information of each ant. ACO technique comes under the swarm intelligence [5]. It is used in various dynamic applications. Ants started from nest in the search of food which is away from nest. Each ant follow different path to reach to the food source and secrete pheromone liquid at the path as a mark to attract other ants. Ants choose the path depending upon the pheromone and path is marked after collecting food. So at the end shortest path has the highest probability. The act of making trail of pheromone liquid is very useful to find out good food source direction. Moreover, ACO [5] deals with a process in which decreasing in amount of pheromone deposited on every path by the time is known as trail pheromone evaporation. When they complete their search to find out best result or to reach final destination, they update their trail to attract other ants. Each combinatorial problem defines its own updating criteria depending on its own local search and global search respectively. Ants are able to find shortest path on the basis of pheromone

information laid on ground by other ants of same colony. Ant searching for food goes for all possible trails, but in last chooses the trail with largest deposit pheromone and update according to the latest pheromones. There is population of ants in ants system, which is working as agent to find out shortest path and communicate with other ants. When reached its destination, the direction of path it follow is based upon the amount of pheromone it detects and is made by decision probabilistically. The whole process shows team coordination, synchronization, team management, how to communicate with others ants.

Advantages of ACO [5][6][7][8]

1. ACO displays powerful robustness.
2. It has an advantage of distributed computation which avoids premature convergence.
3. It is adaptive in nature and can adapt changes easily.
4. It gives positive feedback which leads to discovery of good solutions.
5. It can be used in dynamic applications.
6. To communicate with each other's ant use antennas and pheromone liquid.
7. The whole process is done in an organized manner.

Disadvantages of ACO [5][6][7][8]

1. Its convergence is guaranteed but time to convergence is uncertain.
2. Coding is not straightforward.
3. It is prone to falling in the local optimal solution.

Applications of ACO [5]

ACO is used in routing problem i.e. travelling salesman problem, vehicle routing and sequential ordering.

1. It is applied to solve job scheduling problem, project scheduling and applied in multilevel framework also.
2. It is also used to solve many assignment problems like frequency assignment, graph coloring and quadratic assignment problem.
3. ACO is also applied in the field of networking like optical network routing, connection oriented routing etc.
4. It can be used to solve knapsack problem and set covering problems and applied in fuzzy systems.
5. Nearest neighbor node choosing rule can be solved by using ant colony optimization.

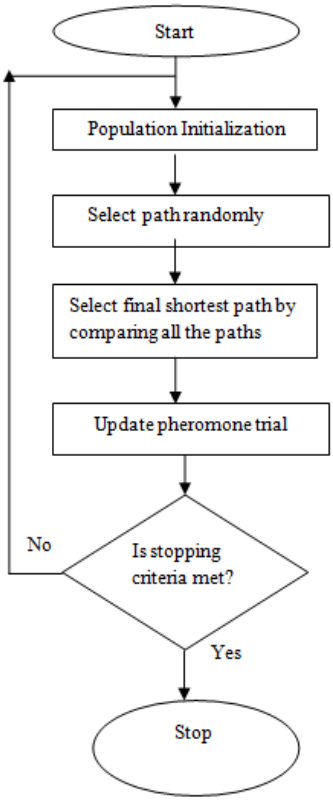

Fig 2: Representing Flow Chart of ACO

4 CONCLUSION

A Bee colony optimization and ant colony optimization both are metaheuristic techniques based on swarm intelligence. Both have no centralized controller and self organizing techniques. In ACO ants back tracking route to food source using pheromones. In BCO, bees use Path Integration and use direct path to come back to hive instead of back tracking their original route. Bee colony optimization algorithm is more efficient than ant colony optimization algorithm as it takes lesser number of steps when finding and collecting the food.BCO algorithm requires less computation time to complete task so it is more scalable.

TABLE I. Comparison between ACO and BCO

Bee Colony Optimization(BCO)	Ant Colony Optimization(ACO)
Bees are working as an agent.	Ants are working as an agent.
Selection of final path is based on FSB table generated by forager bees.	Selection of final path is based on pheromones trials.
Bees return hive through direct path.	Ants return to colonies by back tracking original path.
To communicate with each other's waggle dance is performed in the bee hive.	To communicate with each others, pheromones liquid is used.

It is more efficient than ACO.	It is less efficient than BCO.
It is less adaptive in nature.	It is high adaptive in nature.
It requires less computation time to find result.	It requires high computation time to find out result.
It takes lesser steps to complete whole process than ACO	It takes more steps than BCO to complete whole process.

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