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A Review To: Genetic Algorithm, Ant Colony Optimization and Particle Swarm Optimization Algorithm

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Abstract— This paper presents the concepts of three evolutionary algorithms i.e, genetic algorithm, ant colony optimization and particle swarm optimization algorithm. An evolutionary algorithm copies the way how evolution occurs in the nature . There are various types of evolutionary algorithms. This paper focuses on Genetic, ACO and PSO algorithms. Genetic algorithm provides solution to various optimization problems. It follows the principle of "survival of the fittest". Various problems such as knapsack problem, TSP(travelling salesman problem) can be solved using genetic algorithm. Ant colony optimization is a heuristic algorithm which follows the behavior of ants i.e, the way ants seek food in their environment by starting from their nest. Particle swarm optimization algorithm(PSO) is also an optimization algorithm which also uses a method of searching using some heuristics.

Keywords— Ant colony optimization, Evolutionary Algorithm, Genetic algorithm, Particle swarm optimization algorithm,Swarm intelligence.

I. INTRODUCTION

An evolutionary algorithm(EA) is an algorithm first given by Charles Darwin in 1859. It provides solution to various optimization problems. It copies the process of evolution that occurs in the nature i.e, mutation, recombination and natural selection. GA(Genetic Algorithm) is a type of evolutionary algorithm. GA provides solution to a problem in the form of strings of numbers and applies the operators such as mutation and recombination. It starts from an initial population and by applying these operators finds the fittest generation of population.

An ACO(Ant colony optimization) algorithm is also a heuristic algorithm, first found by Marco Dorigo, which provides an optimal solution by mimicking the way ants find their food. ACO is a type of SI(swarm intelligence) technique.

PSO(Particle Swarm) algorithm, first found by Kennedy and Eberhart, also provides an optimal solution to problems and is inspired by the flock of birds, fishes and by herds of animals. It mimics the way they find food in their environment and follows the approach of information sharing.

This paper constitutes the following sections. Section II illustrates genetic algorithm. the origin of ACO . Section III illustrates basics of ACO(Ant Colony Optimization) algorithm. Section IV illustrates PSO(Particle swarm optimization) algorithm. Section V illustrates conclusion.Section VI illustrates future work. Section VII illustrates references.

II. GENETIC ALGORITHM

GA(Genetic Algorithm) was first given by john Holland in 1970. It is based on the natural evolution and consists of mainly two processes. First process is the initial individual selection and then the second process is the manipulation of individuals by applying operators such as mutation and recombination for generating new population. It follows the principle of "survival of the fittest". First process i.e, selection process, chooses individuals that will reproduce to produce new generation. This process also involves deciding that each selected individual will produce how many offsprings. If this selection process is good then the chances of individuals for being good parent increases.

In Genetic algorithm, evolution occurs iteratively over a population of candidate solutions over manygenerations. A fitness function is used to evaluateeach candidate on the basis of how close it is to thedesired result. The solution's quality should improve over each iteration. Finally, if a solution that is good enough is found, termination of program can be done.

Steps of Genetic algorithm:-

1. Initialization: Random Generation of initial population is done at this step.
2. Selection: Selection of two parent individuals is done at this step according to a fitness function. Higher the fitness, more are the chances of getting selected.
3. Reproduction :-Two chromosomes are selected by following the selection step and crossover or mutation is applied on them to generate new offsprings. If these offspringsarebetter than any existing least fit individual then that least fit individual is replaced by the new offspring.

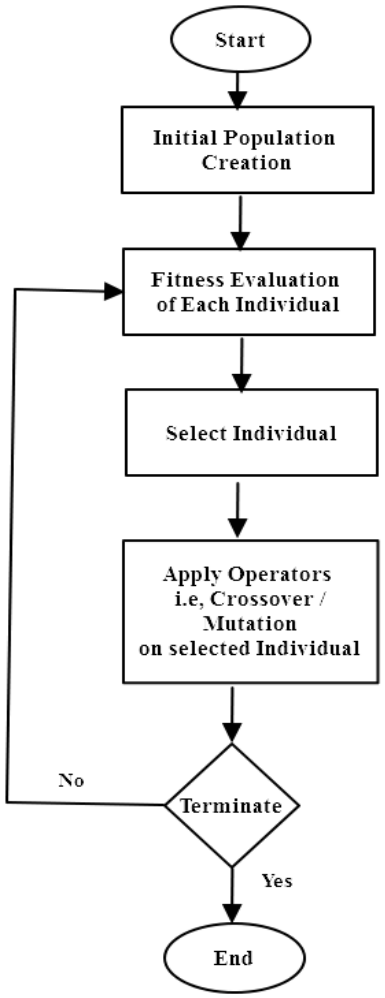


Fig1: Flow Chart of Genetic Algorithm

4. Crossover: At this step, parents are crossovered/ recombined to generate new offsprings.
5. Mutation:- Mutation is performed to maintain genetic diversity across generations.
6. Replacement: Old individuals are replaced with new offsprings at this step.

III. ANT COLONY OPTIMIZATION ALGORITHM

ACO was initially given by Marco Dorigo. This algorithm is inspired by the behavior of ants in the real world. Ants follows the principle of survival of colonies rather than survival of the individual as they always stay in their colonies. Ants are known for doing very difficult tasks in a very simple way. They search the path which is the shortest one between a food source and their nest. Initially, they wander randomly in their environment. While exploring the path, they deposit a chemical i.e, pheromone on their path which they visit. If an ant finds food, it again goes back to its nest by again depositing that pheromone trail on the ground. Other ants smell these pheromone trails. The chances of an ant choosing a path depends on the amount of pheromone deposited on that path. Higher the pheromone concentration on the path , probability of selecting that path by other ant also gets higher. So, the probability of choosing a path and density of pheromone are directly proportional.

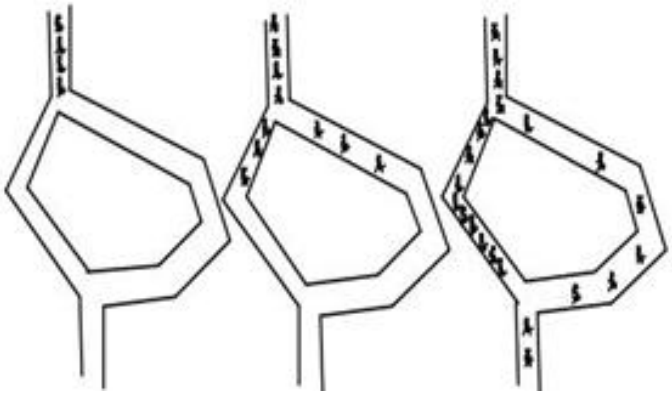
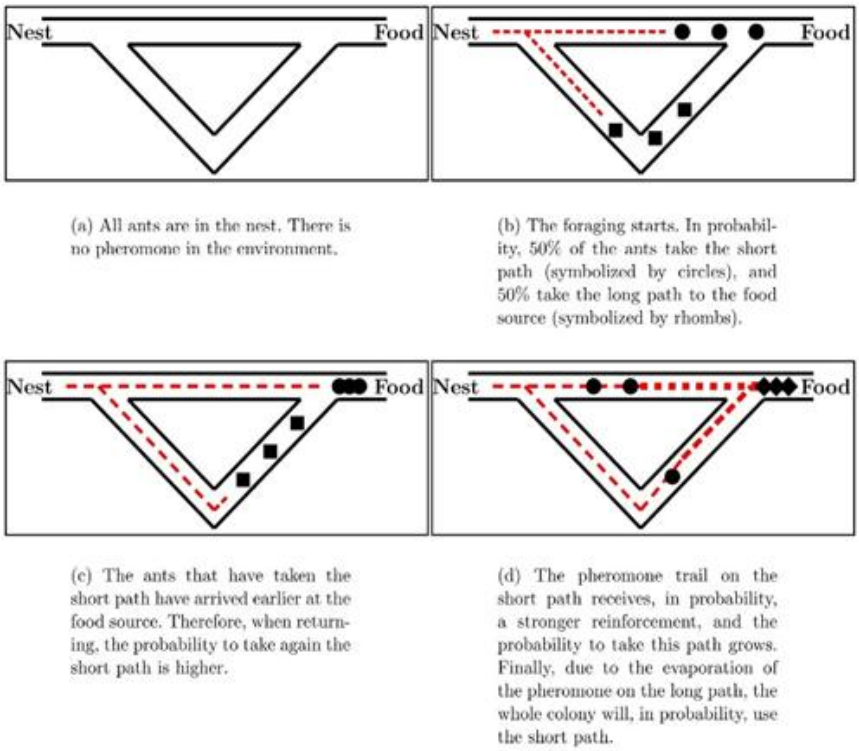


Fig2: Sketch Map of the Ant Theory



(a) All ants are in the nest. There is no pheromone in the environment.

(b) The foraging starts. In probability, 50% of the ants take the short path (symbolized by circles), and 50% take the long path to the food source (symbolized by rhombs).

(c) The ants that have taken the short path have arrived earlier at the food source. Therefore, when returning, the probability to take again the short path is higher.

(d) The pheromone trail on the short path receives, in probability, a stronger reinforcement, and the probability to take this path grows. Finally, due to the evaporation of the pheromone on the long path, the whole colony will, in probability, use the short path.

Fig3: Behavior of ants

The above figure shows how ants find their food in the environment.
In fig.(a), no ant is searching for food. They are in their nest. So, no chemical is there on the path.

In fig.(b), ants have started exploring the path to find the food. Different ants will follow different paths and they will keep on depositing the pheromone on the path which they will follow. Some ants will follow the path shown by circle and some by rhombus.

In fig.(c), the ants that follow the path depicted by circle will reach the food source earlier as compared to ants that follow the path depicted by rhombus. It shows that path shown by circles was the shorter one. So, when the ants will go back to their nest, their chances of choosing thepath shown by circle will increase.
In fig.(d), density of pheromone on the path depicted by circle will be more.
The ACO algorithm is as follows:-

```
While conditions for termination do not met{
ActivitesSchedule
SolutionConstructionBasedOnAnts()
UpdatePheromone()
DaemonActions()
  }
```

In the above algorithm DaemonActions() part is optional. ACO is an iterative algorithm in which the while loop controls the run time of this algorithm. In SolutionConstructionBasedOnAnts(), a colony of ants build a set of solution. These solutions are then evaluated based on an objective function. In UpdatePheromone(), two opposite mechanisms are used i.e, pheromone deposit and pheromone evaporation. In pheromone deposit, artificial ants increase pheromone values on visited components connections. In pheromone evaporation, ants decrease the values of pheromone trails on all connections by a same value. In DaemonActions(), the daemon may decide to deposit extra pheromone on the solution components that belong to the best solution found so far.

IV. PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization(PSO) was originally found by Dr. Kennedy and E berhart in 1995. Like ACO, it is also based on swarm intelligence. It is inspired by the bird and fish flock movement behavior. Birds search for food by scattering or going together in groups. While searching, there is always a bird who has better food resource information, and who is perceptible of the place where food can be found and it can smell the food very well. Because Birds transmit the information about food source to each other, that's why they flock at the place where food can be found. This algorithm is very simple and has many advantages. That's why, it can be applied to various fields such as, neural network training, machine study etc. In basic PSO, there are "n" particles, and their position gives a potential solution in D-dimensional space. The most optimist position during the movement of a particle and the position of the most optimist particle in the surrounding, both affect the position of the particle.
Algorithm for PSO:-
Initialize the particle position and velocities randomly.
While termination condition not met do

For each particle j
Evaluate Y_j, which is the fitness, at X_j which is the current position
If Y_j is better than P_{bestj}thenupdateP_{bestj} and P_j
If Y_j is better than G_{bestj}thenupdateG_{bestj} and G_j
For each particle j:-
Xj is a vector which depicts the position and Yj denotes value of objective function.
Vj is a vector which denotes velocity of the particle.
Pj is the best position found so far and $P_{bestj}$is objective function score.
Gj is the best position found so far in its neighborhood and $G_{bestj}$is objective function score of Gj.
In updating velocity, new velocity is created by three terms:-

1. Inertia Term, because of which particle go in direction same as before by applying adjustments to old velocity.
2. Cognitive Term(Personal best), because of which particle moves back to position which was best previously.
3. Social Learning Term, because of which particle goes back toneighbor's previous best position.

PSO can be applied to both engineering problems and scientific research as it is based on intelligence. There are no mutation calculation in PSO like genetic so, it is very simple.

V. CONCLUSIONS

In this paper, a review to three evolutionary algorithms, i.e, Genetic algorithm, Particle Swarm Optimization(PSO)andAnt colony optimization(ACO) is given. Genetic Algorithm copies the way evolution occurs in the nature, while ACO is based on the behavior of ants and PSO is based on the behavior of flock of birds and fishes. All these algorithms can be used to solve various optimization problems.

VI. FUTURE WORK

This paper provides a review to Genetic, ACO and PSO algorithms. In the future, enhancements can be done in these algorithms to provide better solutions to optimization problems. Also these algorithms together can be compared with each other to find most effective algorithm. These algorithms can also be combined together to make a hybrid algorithm to solve various problems.

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