**ANT COLONY OPTIMIZATION**

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**INTRODUCTION**

All the decidable problems which are in existence can be classified into three classes based on the level of complexity namely P, NP and NP-Complete.

P: The problems whose solution or algorithm for the solution can be determined in polynomial time complexity.

NP: Given a problem and a certificate, the problems whose certificates can be validated to be as solutions or not in polynomial time complexity fall under NP.

A problem Q is said to be in NP – Complete if

1. Q is in NP
2. For some other P in NPC, P is reducible to Q in polynomial time.

The extreme cases of NP – Complete are treated to be NP – Hard.

NP – Hard: Discrete Combinatory problems for which no optimal algorithm exists.

**Approximation techniques**

There might not be any perfect solution to such problems but a solution may be found out with some approximations. There are two types of approximation techniques. They are:

1. Local Search/Optimization: Iteratively improves a complete solution (assumed by some means) till it reaches optimality.

Example: For transportation cost minimization algorithms, we take the solution of either Northwest corner method/ Least Count Method/ VAM Method and iterate it using MODI Method to obtain the optimal solution.

1. Construction Algorithm: Builds a solution using some problem – specific heuristic information.

Example: For a TSP, we start from a node and based on some strategy/heuristics, we build the entire network.

Ant Colony Optimization (ACO) algorithms are construction heuristic algorithms with an ability to exploit experience gathered during the optimization process.

**Construction Algorithms**

The initial solution is a null set i.e. we start empty handed from a point and reach the optimality by building the elements of the solution.

Build solutions to a problem under consideration in an incremental way starting with an empty initial solution and iteratively adding opportunely defined solution components without backtracking until a complete solution is obtained.

Merits and Demerits:

1. Fast and Reasonable solutions
2. Quality of optimality meets the requirements but may not be up to the mark i.e. the obtained solution might be far from the real optimal solution.
3. Only limited number of solutions can be generated.
4. Decisions made at early stages may increase/decrease your steps at the latter stages.

**Ant Colony Optimization**

It is a probabilistic model. The name and method originated from the basic idea of ants obtaining their path from their colony to the source of food in an optimal manner by use of pheromones. The model was proposed by Marco Dorigo.

ACO is a paradigm for designing meta-heuristic algorithms for combinatorial optimization problems. Metaheuristic algorithms are algorithms which, in order to escape from local optima, drive some basic heuristic: either a constructive heuristic starting from a null solution or adding elements to build a good complete one, or a local search heuristic starting from a complete solution and iteratively modifying some of its elements in order to achieve a better one.

The essential part of the ACO algorithms is that they are the combination of the priori information about the structure of a promising solution with a posteriori information about the structure of the previously obtained good solutions.

In the case of ACO, the probability distribution is explicitly defined by previously obtained solution components.

Ants navigate from their colony to the food source leaving pheromone trails in the path. More number of pheromone trails increases the probability of the shortest path and there by leading to an optimal shortest path from their colony to the food source.



For example, let us consider the famous travelling salesman problem.

Virtual trails are accumulated on path segments. Path is selected at random based on amount of "trail" present on possible paths from starting node. Ant reaches next node, selects next path and continues until it reaches starting node. Finished tour is a solution. Tour is analyzed for optimality.

ACO can be applied to any discrete optimization problem for which some solution construction mechanism can be conceived.

Artificial ants are stochastic solution construction heuristicsthat probabilistically build a solution by iteratively adding solution components to partial solutions by taking into account,

* heuristic information on the problem instance being solved, if available,
* (Artificial) pheromone trails which change dynamically at run-time to reflect the agents’ acquired search experience.

Stochastic componentallows generating a large number of different solutions.