Introduction to Ant Colony Optimization (ACO)

Soft Computing
CSE 4237

Evolutionary Algorithms

- When algorithms are inspired by natural laws, interesting results are observed.
- Evolutionary algorithms belong to such a class of algorithms.
- These algorithms are designed so as to mimic certain behaviours as well as evolutionary traits of the human genome.
- Moreover, such algorithmic design is not only constrained to humans but can be inspired by the natural behaviour of certain animals as well.
- The basic aim of fabricating such methodologies is to provide realistic, relevant and yet some low-cost solutions to problems that are unsolvable by conventional means.

Evolutionary Algorithms

- Different optimization techniques have thus evolved based on such evolutionary algorithms and thereby opened up the domain of metaheuristics.
- Metaheuristic has been derived from two Greek words, namely, **Meta** meaning one level above and **heuriskein** meaning to find.
- Algorithms such as the Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) are examples of swarm intelligence and metaheuristics.
- The goal of swarm intelligence is to design intelligent multi-agent systems by taking inspiration from the collective behaviour of social insects such as ants, termites, bees, wasps, and other animal societies such as flocks of birds or schools of fish.

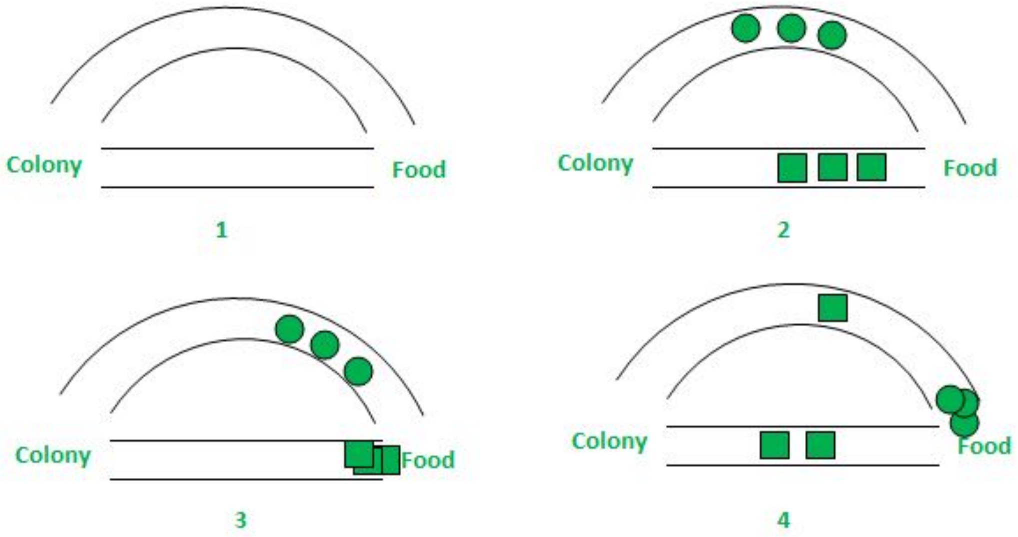
Ant Colony

- Ant Colony Optimization technique is purely inspired from the foraging behaviour of ant colonies, first introduced by Marco Dorigo in the 1990s.
- Ants are eusocial insects that prefer community survival and sustaining rather than as individual species.
- They communicate with each other using sound, touch and pheromone.
- Pheromones are organic chemical compounds secreted by the ants that trigger a social response in members of same species.
- These are chemicals capable of acting like hormones outside the body of the secreting individual, to impact the behaviour of the receiving individuals.
- Since most ants live on the ground, they use the soil surface to leave pheromone trails that may be followed (smelled) by other ants.

Ant Colony Optimization

Ants live in community nests and the underlying principle of ACO is to observe the movement of the ants from their nests in order to search for food in the shortest possible path.

- Initially, ants start to move randomly in search of food around their nests.
- This randomized search opens up multiple routes from the nest to the food source.
- Now, based on the quality and quantity of the food, ants carry a portion of the food back with necessary pheromone concentration on its return path.
- Depending on these pheromone trials, the probability of selection of a specific path by the following ants would be a guiding factor to the food source.
- Evidently, this probability is based on the concentration as well as the rate of evaporation of pheromone.
- It can also be observed that since the evaporation rate of pheromone is also a deciding factor, the length of each path can easily be accounted for.



Stage 1: All ants are in their nest. There is no pheromone content in the environment. (For algorithmic design, residual pheromone amount can be considered without interfering with the probability)
Stage 2: Ants begin their search with equal (0.5 each) probability along each path. Clearly, the curved path is the longer and hence the time taken by ants to reach food source is greater than the other.
Stage 3: The ants through the shorter path reaches food source earlier. Now, evidently they face with a similar selection dilemma, but this time due to pheromone trail along the shorter path already available, probability of selection is higher.
Stage 4: More ants return via the shorter path and subsequently the pheromone concentrations also increase. Moreover, due to evaporation, the pheromone concentration in the longer path reduces, decreasing the probability of selection of this path in further stages. Therefore, the whole colony gradually uses the shorter path in higher probabilities. So, path optimization is attained.

References

1. Ant Colony Optimization by Marco Dorigo and Thomas Stutzle
2. https://www.geeksforgeeks.org/introduction-to-ant-colony-optimization/