

Chapter 5

Intelligent Decision Making Through Bio-Inspired Optimization: Ant Colony Optimization for Real-World Scenarios

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ABSTRACT

Ant colony optimization is a popular metaheuristic algorithm inspired by the foraging behavior of ants. It's often used to solve complex optimization problems. Train scheduling is a challenging problem involving the allocation of train resources, routes, and timetables to optimize various objectives like minimizing travel time, energy consumption. In train scheduling, this usually involves defining nodes and arcs to represent railway stations, tracks, and possible connections to optimize, well-defined, such as minimizing the total travel time or energy consumption. The process of ant movement and pheromone update is repeated for a predefined number of iterations or until a termination condition is met. Vehicle routing problem with time frames, the time dependent VRP, the VRP with pickup and delivery, and the dynamic VRP were developed to bring the VRP closer to the types of situations found in the real world. The optimum route serving all clients utilizing a driver's maximum working hours and minimizing total transportation cost is one solution to this problem.

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ANT COLONY OPTIMIZATION FOR REAL WORLD SCENARIOS

The algorithmic domain is stunning, with several ideas and tools being developed around the clock to suit the demand for high-performance computing. In actuality, algorithms that are inspired by natural principles produce fascinating results. This class of algorithms includes evolutionary algorithms. These algorithms are designed to simulator particular functions and evolutionary characteristics of human DNA. Furthermore, such algorithmic design is not restricted to humans, but can also be stimulated by the natural behaviour of firm animals. The fundamental purpose of developing such practices is to provide practical, related, and low-cost solutions to problems that were previously insoluble using conventional methods.

Several optimisation strategies have emerged based on such evolutionary algorithms. So metaheuristics is introduced into the picture. Metaheuristic is imitative from two Greek words: meta, meaning “one level above,” and heuriskein, meaning “to find.” Particle Swarm Optimisation (PSO) and Ant Colony Optimisation (ACO) are swarm intelligence and metaheuristic algorithms, respectively. Swarm intelligence seeks to create intelligent multi-agent systems based on the cooperative behaviour of social insects such as ants, termites, bees, and wasps, as well as other animal societies such as bird flocks or fish schools.

Marco Dorigo invented the Ant Colony Optimisation approach in the 1990s, which was fully inspired by ant colonies’ foraging behaviour. Ants are eusocial insects, meaning they choose collective endurance and sustainability over each species survival. They communicate using voice, touch, and pheromones. Ants create organic chemical substances called pheromones, which cause members of the same species to engage socially. These are compounds that can impact the behaviour of recipients by functioning as hormones outside of the secretor’s body. Because most ants dwell on the ground, they consent pheromone trails on the soil surface for other ants to follow (smell).

Ants live in open nests, and the basic assumption of ACO is to perceive ants’ drive away from their homes in order to obtain food in the shortest possible path. Ants begin to wander aimlessly in hunt of food around their nests. This randomised search enables multiple routes from the nest to the food supply. Now, depending on the class and measure of the food, ants transport a portion of it back with the appropriate pheromone concentration on its return voyage. Depending on the results of these pheromone trials, the chance of the next ants taking a specific path will serve as a pointer to the food source. Clearly, this likelihood is governed by the pheromone’s concentration and rate of evaporation. It is also worth mentioning that, because the pheromone’s evaporation rate is a key factor, the length of every path can be easily calculated.

Ant Colony Optimisation (ACO) is a nature-inspired optimisation technique that excels at solving combinatorial optimisation problems. It is based on the foraging activity of real ants, which seek the shortest route between their nest and a food source. ACO has been effectively utilised in a variety of real-world contexts, including train scheduling and vehicle routing algorithms.

Ant Colony Optimization Pseudocode

```
procedure AntColonyOptimization()  
  initialize pheromone levels on all edges  
  repeat until termination criteria are met:  
    create a population of artificial ants  
    for each ant in the population:  
      construct a solution using pheromone levels and heuristic information
```

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