Ant Colony Optimization

The Ant Colony Optimization algorithm is inspired by the foraging behaviour of ants. The behaviour of the ants is controlled by two main parameters: α, or the pheromone's attractiveness to the ant, and β, or the exploration capability of the ant. If α is very large, the pheromones left by previous ants in a certain path will be deemed very attractive, making most of the ants divert its way towards only one route (exploitation), if β is large, ants are more independent in finding the best path (exploration). This ACO implementation used the Ant-System (AS) variant where the movement from node i to node j is defined by:

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{\tau_{ij}^{\alpha}(t)\eta_{ij}^{\beta}(t)}{\sum_{u \in \mathcal{N}_i^k(t)} \tau_{iu}^{\alpha}(t)\eta_{iu}^{\beta}(t)} & if \quad j \in \mathcal{N}_i^k(t) \\ 0 & if \quad j \notin \mathcal{N}_i^k(t) \end{cases}$$

This equation calculates the probability of selecting a single component of the solution. Here, tij denotes the amount of pheromone on a component between states i and j, and nij denotes it's heuristic value.

Methodology

The α and β parameters control the exploitation and exploration behaviour of the ants by setting the attractiveness of pheromone deposits or the "shortness" of the path. The local pheromone update process is applied every time an ant successfully constructs a solution. This step mimics the way ants lay pheromone trails after finding food in nature. Better paths acquire more pheromone due to ants being able to traverse them quicker. In ACO, this characteristic is replicated by varying the amount of pheromone deposited on a component by considering how well the completed solution scores.

Global Pheromone Update

The global pheromone update is the stage in which pheromone is evaporated from components. It is applied after each iteration of the algorithm, when each ant has successfully constructed a tour and applied the local update rule.

$\tau ij \leftarrow (1-\rho)\cdot \tau ij$

Where τij is the pheromone on the component between state i and j and ρ, is a parameter used to vary the level of evaporation.

In ACO, arriving at the best solution requires balancing the exploitation-exploration trade-off. Setting the evaporation coefficient low makes the pheromones stay longer. However, this can be balanced by setting the path bias of the colony very high, so that they get to explore more options near the route with the highest pheromone concentration (instead of blindly settling in it).