Simulation Championship

Ant Colony Simulation

Introduction:

We would like to study swarm intelligence by simulating the behavior of an ant colony. Although ants are primitive creatures, they are able to perform complex tasks in groups, such as foraging efficiently for food, protecting their nests etc.

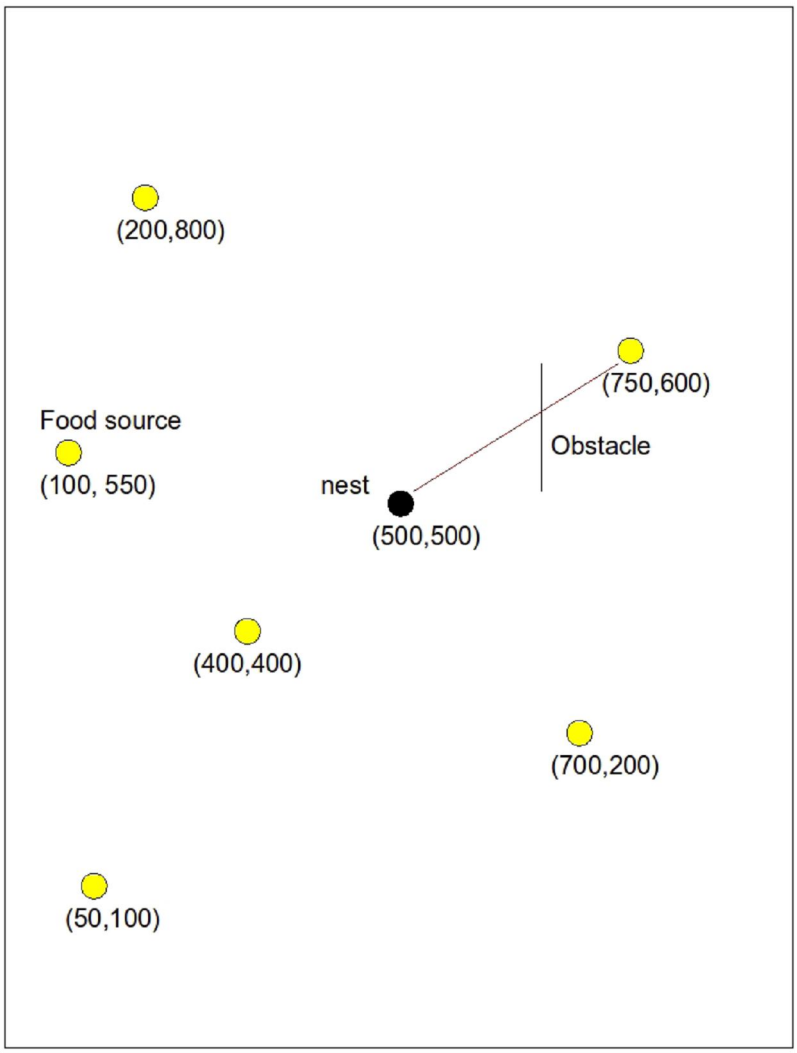
The main assumption involved while modelling swarms is that each entity is a simple agent, which is able to interact only locally with fellow agents. There is no centralized, global control over each individual ant; every ant follows a simple set of rules, so that the colony as a whole appears to be displaying intelligent behavior.

Ants are able to communicate through certain chemicals called pheromones, which they are able to release at will. For example, when a foraging ant finds a route from a food source to the nest, it marks it with a pheromone trail to alert other ants of the presence of food. Similarly, when it is being attacked by rivals. Stronger the pheromone concentration, more is its radius of influence.

Problem Description:

Objective:
Simulate an ant colony behaviour and show how ants are able to pick out the optimum (shortest) paths from their nests to food sources.

Map:



The arena is a 1000*1000 grid , with the given initial conditions. The map is not drawn to scale.

Ant Attributes:

- Ants are born from a nest after every tb time units. Each ant lives for a period of t_d time units, unless it dies prematurely from long periods without food ($t_{d,f}$ time units is the maximum such time possible without food). An ant replenishes its hunger whenever it reaches the nest or a food source.
- Pheromones are of two kinds- exploration and trail:
    - Exploration pheromones are laid out by ants who are searching for food and need a means to get back to the nest once they locate such food sources. These pheromones are followed only when the ants have food with them and need to return to the nest. An ant will only follow its own exploration pheromone. All exploration trails must have one of their ends at the nest.
    - Trail pheromones are laid out by ants carrying food, and returning to the nest. Once an ant has found food, it returns back to the nest and masks the exploration pheromone with a trail pheromone, which other ants may follow.
- Pheromones are volatile chemicals- they evaporate over time. You may experiment with different rates of evaporation.
- If a food source gets depleted, the ant will return back to the nest following the trail, but this time won't deposit any trail pheromone.
- An an leaving the nest (after birth, or after depositing food, or returning empty handed) may choose to follow an existing trail pheromone with a probability of 0.8, or start exploring for new food sources (0.2).
- Each ant is able to carry d food units at a time.

Ant movement:

- Ants are known to follow optimized search paths between the nest and food sources without prior knowledge of the environment. Consider that 2 paths A and B have been found to a certain food source F from the nest N, by two different exploration ants. The shorter one, say A, would eventually have more trail pheromone deposited over it, since ants following it would have made a larger number of trips on it. Trail B would fade away with time and A would remain as the dominant, shorter path.
- Ants move on the edges of the grid, from one lattice point to the other. At every point, they have the option of moving in four mutually perpendicular directions. These four edges have trail and exploration pheromones of varying concentration. If the ant is exploring, it will follow a random direction, otherwise it will follow the direction with the highest trail pheromone concentration. Make sure to avoid ants moving on never-ending loops.

Demonstrations:

- Vary different parameters such as ant age, max hunger span, birth rate, max quantity of food that can be carried etc. and show the effects on the simulation.
- Ants are known to follow the shortest path trails from the food to the nest, without following any pre-calculated routes. Does your model guarantee that ant trails from food to nest are the most optimum possible?
- A high pheromone evaporation rate would force ants to clear up food sources quickly lest the trail disappear. On the other hand, a low rate of evaporation would cause ants to follow trails to sources which have currently been depleted. Is there any optimum rate of pheromone evaporation? If so, how does it depend on factors such as quantity of food in the concerned food sources?
- [Bonus] Sometimes, established ant trails are disturbed by fallen obstacles. Randomly introduce an obstacle in one of the ant trails such as that shown in the _gure. Show how the ants adapt and modify their trail to wind around the obstacle.