Go to the Ant .... Consider her Ways and be Wise

A.H. Harker

November 2011

Introduction

In the fim *Antz* there is a scene in which ants are brought before clipboard-wielding bureaucrats and each ant is stamped and allocated a task. Ants don't really work that way, so how do they organize themselves? According to researcher Deborah Gordon (cited by Miller[1]) "if you watch an ant try to do something, you'll be impressed by how inept it is....The longer you watch an ant the more you end up wanting to help it. *Ants* aren't smart, ant *colonies* are."

[1] Peter Miller. *Smart Swarm*. Collins, 2010. ISBN978-0-00-727990-6

Ants achieve what seem, viewed from a distance, to be extraordinary feats of organisation and cooperation using chemical signals and very simple rules. This project begins by exploring how those signals and rules can solve a problem in the ant world, and then goes on to try to solve a problem in the commercial world.

Stocking the Larder

Given a nest and a source of food, ants have been observed to locate rapidly the optimal path along which to transport their supplies. One particular species was observed by Deneubourg and co-workers[2]: this species lays a chemical trail of pheromones both when seeking food and when carrying food back to the nest. When confronted with a decision as to which path to take, an ant will follow the path with the strongest pheremone trail. Explore how this works in the following way.

[2] J-L Deneubourg, S Aron, S Goss, and J M Pasteels. The self-organizing exploratory pattern of the Argentine ant. *Journal of Insect Behavior*, 3(2):159–168, 1990

- define a region, conveniently set up as a rectangular grid of square blocks;
- define a nest site and a food source in the region;
- initially, define two allowed paths through the region between nest and food (there are various ways in which you might do this);
- set the pheromone levels in all the blocks to zero;
- release the ants and advance time click by click:
  - at each tick of the clock, each ant moves one space;
  - if there is a choice of moves, pick where to go either probabilistically or simply by choosing the strongest pheromone signal;
  - avoid backward steps either by an angular weighting function or by disallowing a move to the place the ant was at the last

tick of the clock – with suitable modification if the ant is at the food source or back at the nest;

- increase the level of pheremone in the block the ant steps to;
- before the next tick of the clock, reduce the pheromone levels of every block by a factor, say 0.9. You should investigate other 'evaporation rates'.

You should find that the ants soon find the best route. Figure 1 shows an example of a simple model.

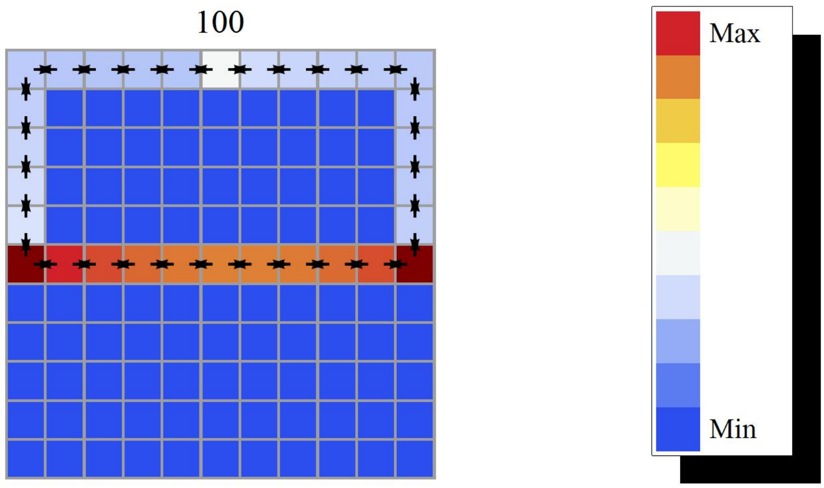

Figure 1: Pheromone tracks along a simple two-choice system between a nest (dark red, left) and a food source (dark red, right). There is a clear preference for the shorter path.

There are various features to experiment with in this model: some are mentioned above, and another is whether to release a cloud of ants all at once or to release them one at a time, on successive ticks of the clock. Think about what might happen, then program it up.

The Travelling Salesman Problem

The travelling salesman problem is one of the classic exercises in optimisation theory. It is simple to state: *a salesman needs to visit a number of cities – what it the shortest path he can take to visit each city once and then return home?* For a small number of cities the problem is trivial, as one can write down all the possible routes, add the distances, and get the answer. The snag is that the number of routes increases as the factorial of the number of cities, and, for example, 30! is 2.65×10^{32}, so enumerating the possibilities becomes impossible.

Marco Dorigo[3] had the idea of applying ant swarm ideas to this problem. In his model, the ants had a bit of global knowledge as well as the chemical signals. His procedure was as follows:

- Place a number of ants randomly on all the cities;

[3] M. Dorigo, V. Maniezzo, and A. Colorni. Ant system: optimization by a colony of cooperating agents. *Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on*, 26(1):29 –41, February 1996

- Move to another city, picking the one to move to probabilistically based on its closeness and the strength of the pheromone trail leading to it;
- When an ant completes a circuit of all the cities, retrace the path back to the starting point, laying a pheromone trail;
- Allow the pheromone to evaporate at a constant rate.

There are some snags: for example, if an ant got temporarily trapped in a small loop of cities, that loop got reinforced – Dorigo allowed intervention to remove such loops.

Implement a version of this scheme. Note that it is not guaranteed to find the optimal route, but it is likely to find a solution that is good enough for practical purposes.

References

[1] J-L Deneubourg, S Aron, S Goss, and J M Pasteels. The self-organizing exploratory pattern of the Argentine ant. *Journal of Insect Behavior*, 3(2):159–168, 1990.

[2] M. Dorigo, V. Maniezzo, and A. Colorni. Ant system: optimization by a colony of cooperating agents. *Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on*, 26(1):29 –41, February 1996.

[3] Peter Miller. *Smart Swarm*. Collins, 2010. ISBN978-0-00-727990-6.

A.H. Harker
November 2011