A Study Of Ant Foraging Behaviour

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ABSTRACT

Ants and other "social organisms" are capable of achieving, what would at first glance appear to be complex tasks.Individually ants have a very limited cognitive capabilities,having less than 250,000 neurons,but collectively they perform very complicated tasks such as Foraging,Nest building,etc. with ruthless efficiency.It's been established by various studies that ants optimise their path so that a minimum work can be done.Here we tried to replicate a very famous experiment where ants are constrained to follow a binary bridge from their nest to the food source and see over time that they converge to one path.We successfully replicated the experiment on various bridges and observed the convergence mostly in a shorter path. In addition, we implemented a new computational model of ant foraging that was proposed by *Theraulaz et. al.* This new model characterizes the "choice-function" of the individual ant as a linear function as opposed to non-linear functions that were previously proposed.

INTRODUCTION

Ants perform a lot of complicated tasks ranging from nest building with various floors and compartments to waste management.Ants interact with one another through various chemicals,called 'pheromones', and these chemicals may vary from one species to another.Especially in case of foraging they navigate on the basis of pheromone concentration in the arena. Once they found the food they leave a pheromone trail while bringing it back to the nest which is sensed by other other ants and that in turn leads to the food source.

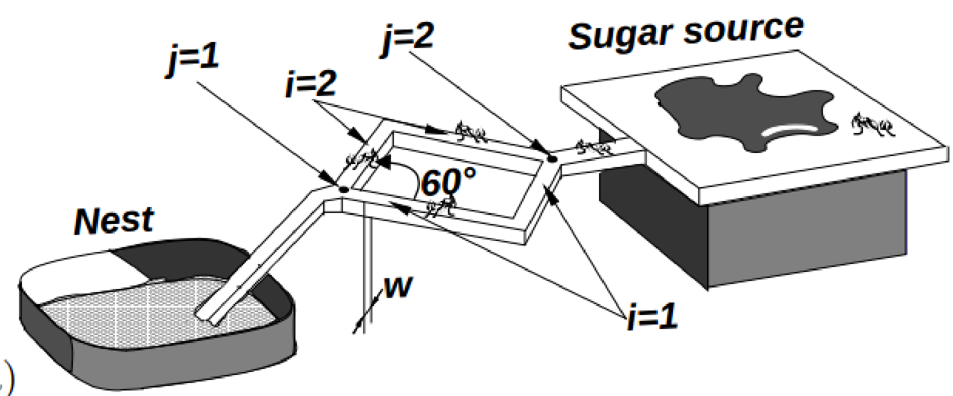
The most popular models of collective foraging behaviour (which have been known since ~1989-90) can be briefly summarized as :

- While returning from the food source to the nest, ants deposit a trail of pheromone leading back to it.
- The ants usually follow the trail of previously deposited pheromone when they leave their nest. If they reach a junction with two possible paths of equal length and different quantities of pheromone then the probability of taking the two paths is given by :

$$p_1 = \frac{(x_1 + \alpha)^\beta}{(x_1 + \alpha)^\beta + (x_2 + \alpha)^\beta}, \qquad p_2 = 1 - p_1$$

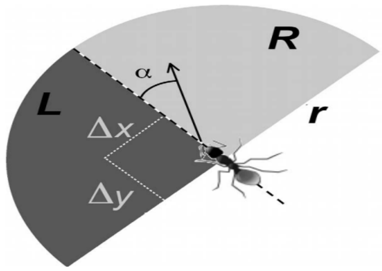
in which x_i is the amount of pheromone on branch 1, α and β are parameters depending on the species.

These rules in addition with the description of the evaporation of the pheromone and a random motion of the ants in addition to the above rules is sufficient to describe with a great deal of accuracy the observed complexity of ant foraging behaviour. As one can notice that the choice function is non-linear because of the parameter β. This binary choice model can be extended to an open arena by imagining it as a set of interconnected binary bridges.A typical binary bridge is shown below:



(a)

Here the nest is surrounded by walls which constraints the ants to follow the binary bridge which leads the ants to a food source.Then the patterns are observed with respect to time. Recently, In a paper titled "Individual Rules for Trail Pattern Formation in Argentine Ants (2012)" Theraulaz *et. al.* have proposed a new model in which the function that describes the motion of ants is linear.



$$\alpha = A\frac{(L-R)}{(L+R)}$$

The angle α is the change from previous direction.'A' is a constant dependent on species. L and R are the integrals of all pheromone in two circular sectors ahead of the ant on the left and right side, respectively.

OBJECTIVE

Experimental:

Replicate the binary bridge experiment with various binary bridges with varying path lengths and observe the convergence patterns

Computational:

Develop a computational simulation for the new model proposed in the paper titled "Individual Rules for Trail Pattern Formation in Argentine Ants (2012)" which various parameters such as total no of ants,velocity,pheromone evaporation rate, etc.

METHODOLOGY

Experimental:

Instead of containing the nest,as shown in the proposed experiment,we contain the food source on an island created in water and the only way to reach the food source would be the binary bridge we provide as shown in the figure below.

Once the set up is established one could observe the convergence patterns.Later the experiment is repeated with various bridges.

Computational:

The model was implemented in JAVA using Netbeans IDE. The basic algorithm can be described as follows:

1. Ants start from their nest with random velocities
2. At every time step they calculate the change in their angle based on the pheromone concentration in their vicinity, as given by the model.
3. Every few time steps ants leave a pheromone mark
4. The pheromone has a characteristic half-life and at every time step the new pheromone concentration at that point is updated.
5. If an ant goes near the boundary, then it simply changes its direction such that it moves along the boundary

OBSERVATIONS AND RESULTS

We performed the experiments with three types of bridges-

- Binary bridge(Equal path length)
- Binary bridge(different path)
- A bridge with three pathways

Experiments have been repeated multiple times with all the three bridges at the same nest and it's been observed that they distribute decently on both sides initially and converge into one path over a period of time even in the symmetric path.In most cases they converge into shorter path.
It took nearly 10-12 minutes for this process and a few times much longer ~20 minutes.

Thus, we have successfully replicated the classic experiment by *Deneubourg et. al.* studying ant foraging on a binary bridge, in addition we have tested the hypothesis on bridges with different path lengths and shapes.

In the computational part, we successfully implemented the model by *Theraulaz et. al,* that generates the trail pattern for any given set of parameters.

RELATED LINKS AND REFERENCES

1. Detrain, Deneubourg – "Self-organized structures in a superorganism: do ants "behave" like molecules?" (2006)
2. Perna et. al. - "Individual Rules for Trail Pattern Formation in Argentine Ants (Linepithema humile)" (2012)
3. Deneubourg et. al. - "The Self-Organizing Exploratory Pattern of the Argentine Ant" (1990)
4. Karsten Peters et. al.-"ANALYTICAL AND NUMERICAL INVESTIGATION OF ANT BEHAVIOR UNDER CROWDED CONDITIONS"
5. Video link for the Ant Convergence Patterns