1D MODEL OF TRAIL PROPAGATION BY ARMY ANTS

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1. Summary

This article tried to model propagation of raiding columns by Army Ants aka swarming behaviors using PDEs. The model looked at the density of the trail network, follower, and leader ants. Leader and pioneer ants were used interchangeably in this article. Pioneers move and turn faster whereas followers were the complete opposite who turned less and were slower. The paper tried to answer the question whether the differences in the behaviour of ants following trails and those exploring new ground, and on the known properties of the trail pheromones changed the swarming behavior or propagation of the raiding columns. The change in properties of the trail networks can be studied as phase transitions. To analyze the model, the author first reduced the system of PDEs to a system of ODEs whose solutions represent travelling waves.

2. Main PDE

$$\frac{\delta}{\delta t}T(x,t) = -\gamma T(x,t) + \tau_f F(x,t) + \tau_l L(x,t)$$

The PDE describes the evolution of the length density of the trail network. $T(x,t)$ is density of trails at position x at time t. $F(x,t)$ is density of trail of followers at position x at time t. $L(x,t)$ is density of pioneers at position x at time t. γ is the rate of decay of the trails' pheromone with an assumption that the total length of the trails in a given region decays exponentially. The author assumed that ants mark the trails using only a single pheromone which is secreted continuously and at a constant rate. τ_f is the rate of trail reinforcement by followers. τ_l is the rate of trail deposition of pheromones by pioneers.

3. Results

The author concludes that small changes in behaviours of the individuals can give rise to a switching between diffuse trail networks and concentrated trail columns. The PDE answers their question of the shape and speed of the ant swarm. The author found that there was little evidence to support or even refute the prediction that achieving a travelling wave propagation at observed velocities were 10% that of the speed of the followers would imply that ratio of pioneers to followers would be $9:1$.

4. Extensions

Even though there were discussions stating that 2-D model would be difficult to analyze, the authors have made it possible to model the motion of automata interacting with a trail network in 2-D as long as there's no spatial dependence to examine the patterns and conditions necessary for a transition from a loose network of trails to a network with strong directional order.

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