Ant colonies and pheromone based foraging

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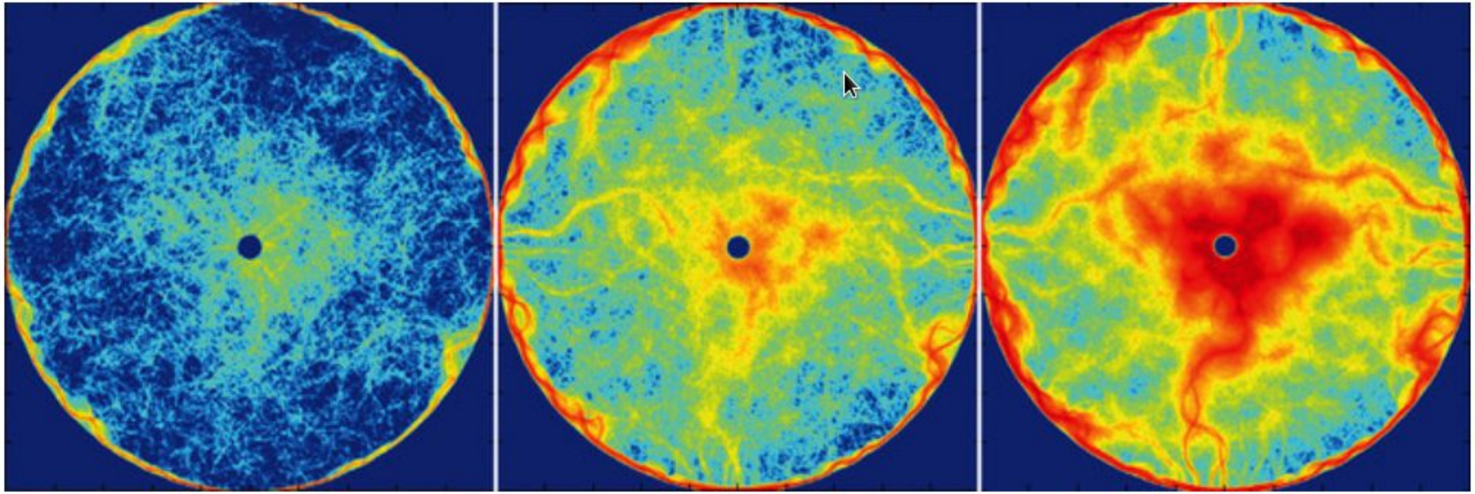
1. Motivation

Emerging behaviour systems

Ant colony optimization algorithms

Modeling biological systems

Observation of patterns that emerge as a result of their movement



2. Related work

Ant movement is affected by:

- random movement policy
- presence of pheromones
- current direction persistence
- response to overcrowding.

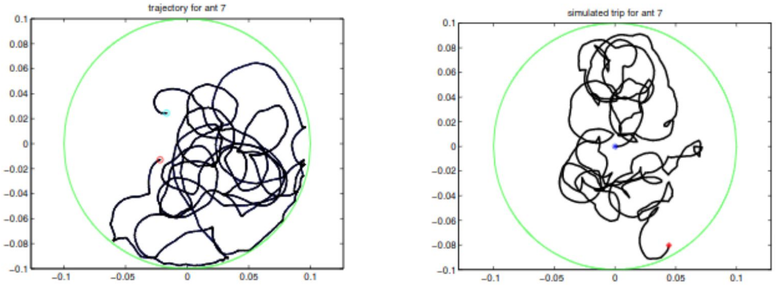


Figure 1. Example of real ant trajectory (left) and simulated movement (right).

Mixture of Pareto and Gaussian distribution fits experimental observation.

2.1 Environmental effects on movement

Most important factors that modulate ant movements:

- pheromone concentration
- presence of boundary
- overcrowding

$$D_{(t+1)} = D + \vec{e_\theta} \ + \frac{\delta \vec{F}}{1 + \nu | \vec{F} |},$$

$$e^{\frac{|\vec{x} - \vec{x_a}|^2}{d^2}}$$

$$\vec{F} = \sum_n \frac{1}{1 + \epsilon} \frac{P_n - P_a}{| \vec{x_n} - \vec{x_a} |^2} (\vec{x_n} - \vec{x_a})$$

3. Methods

Experiment was run in two different environments:

- double-bridge (symmetric and asymmetric),
- open world.

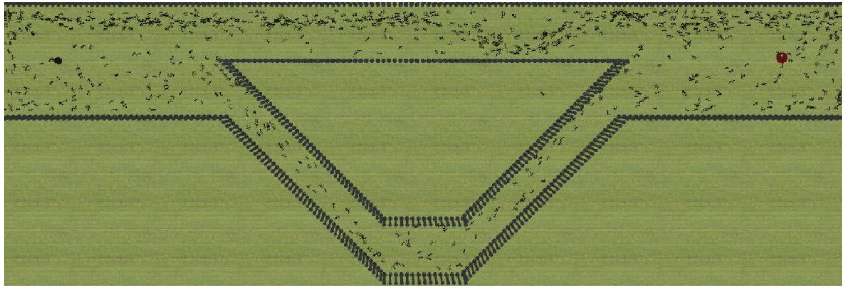
We observed:

- number of ants,
- total food collected,
- food collected per 100 iterations,
- food per ant in last 100 iterations.

3.1 Double-bridge experiment recreation

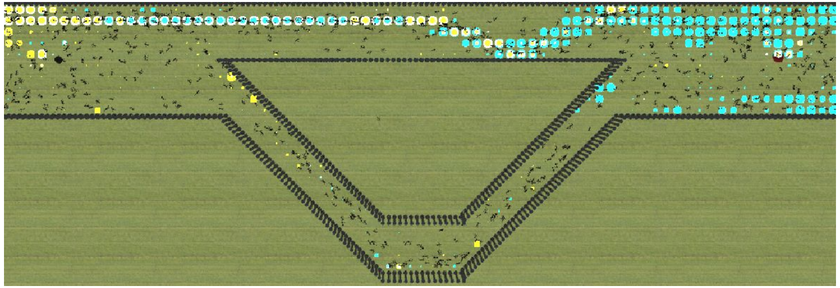
Two types of pheromones can be observed:

- to-food pheromones,
- to-home pheromones.



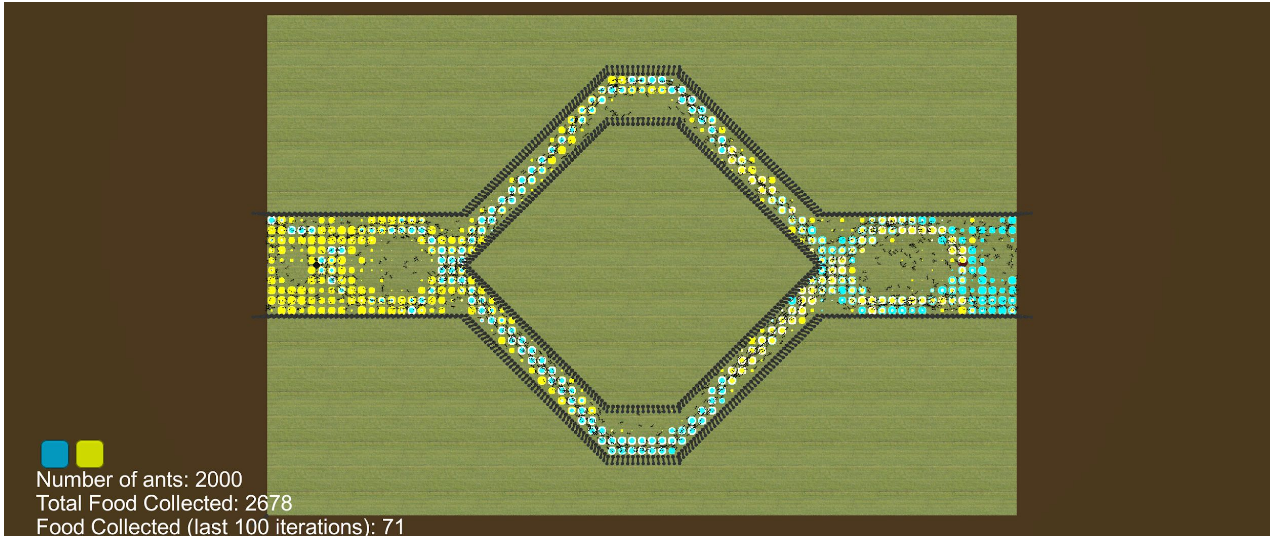
Pheromones do

- secrete,
- evaporate over time.



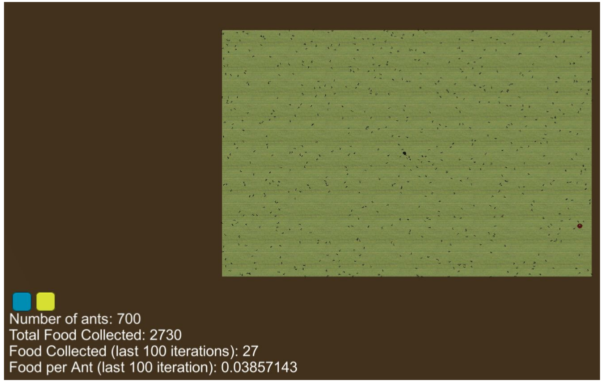
The strength of pheromone is proportional to the size of the coloured mark.

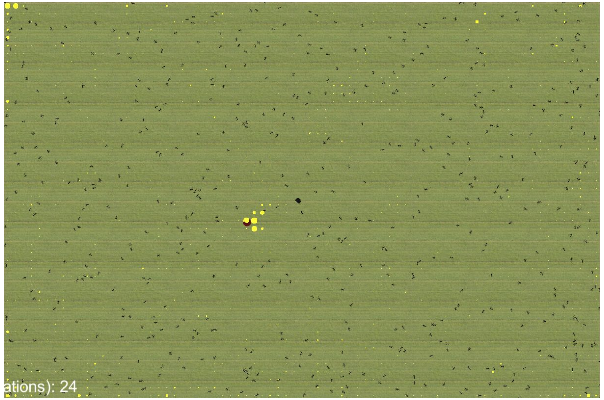
3.2 Double-bridge experiment recreation



3.2 Open world simulation

Results of this simulation corresponds with the fact that the ants form multiple paths from nest to food sources across the map.





4. Implementation

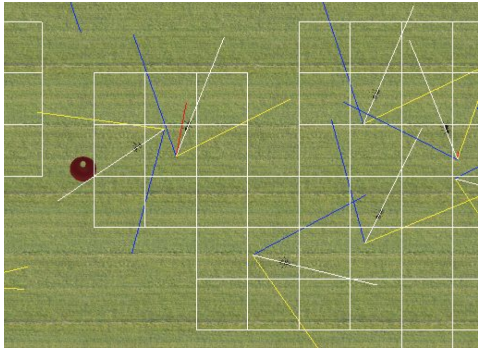
We used the following technologies in Unity to make simulations really efficient:

- ECS (Entity component system),
- jobs with bust compiler,
- quadrant system.

Behaviour of an ant

We used gizmos lines in order to see what is happening:

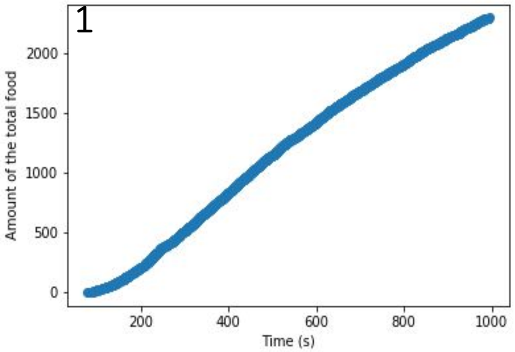
- red line follows the blue pheromone trail,
- other lines determine the direction the ant is facing.

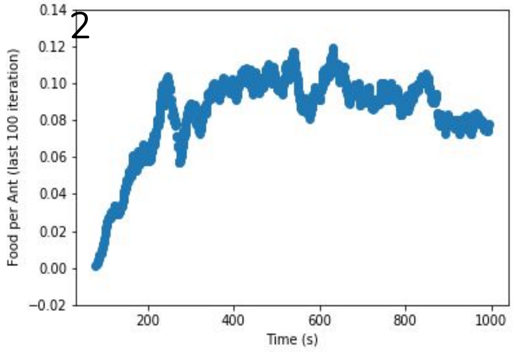


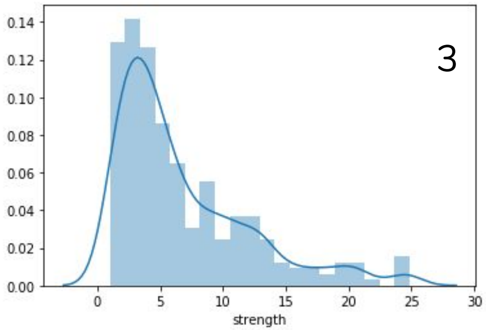
5. Results

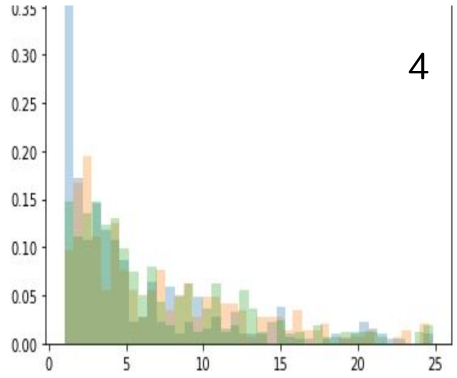
We have gotten the following results:

- amount of collected food is increasing approximately linearly (graphs 1, 2),
- distributions of pheromone strength searching for the food(graphs 3,4).

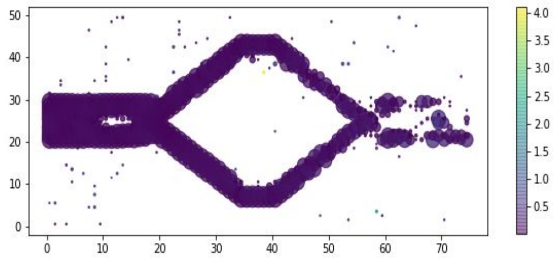


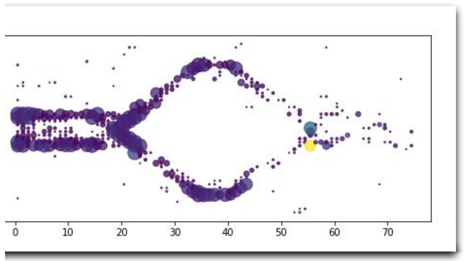






5.1 Qualitative results





- Asymmetric bridge: the results we achieved here were as predicted. Ants have chosen a shorter path in a rather short amount of time.
- Open world: we achieved results as predicted in the literature (multiple paths to food) but stumbled across a rather strange problem: ants began getting stuck in corners of the map forming stronger trails with time.