Simulating Ant Colonies To Investigate How Minor Worker vs Major Worker Ant Distributions Affect Colony Energy

Harry Howarth, Frazer Bennett-Wilford and Blayze Millward

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Abstract

Ant colonies have the unique ability to dynamically search the terrain surrounding their environments, detect and retrieve sources of food. This is an emergent behaviour that has been well well explored by a variety of past studies [**?**] often with a focus on examining the way that paths to and from food sources are created and organised. In reality, many species of ants have a number of different castes of ants within their ranks [**?**]. This study examines what affect different distributions of two castes of ants in particular – the *minor-* and *major-worker* ants – within a colony have on that colony's overall health when faced with differing conditions.

Ant colonies are simulated in Matlab on train that has been descritised into chunks, and food is spawned randomoly throughout the terrain. Ant colonies with differing ratios of simulated minor and major worker ants are created, and their success – as measured by [MEASUREMENT HERE].We found that [FINDINGS HERE] These findings indicate that [INSIGHT INTO ANTS HERE], indicating that a mix of major and minor workers is the most suitable – with the minor workers excelling at [SOMETHING?] while the major workers [DO SOMETHING ELSE], as seen in nature [CITE THIS ACTUALLY HAPPENING - Or, I guess don't if it doesn't really happen and just state that our model was wrong.]

1 Introduction and Background

Ants are *eusocial* creatures, meaning that they possess the highest level of organisation that any social species of animal can possess[?, ?]. Behaviour allows them to perform incredible feats as a whole, even when individually each ant has very little actuation over it's environment. One such example of this is an ant colony's ability to forage for food from its surrounding area, while avoiding obstacles and successfully navigating changes in its environment. This ability in itself has been examined a significant amount in past research[?, ?], and has even lead to algorithmic methods inspired by the behaviour being developed to solve problems faced in areas of computer science, such as those similar to the *travelling salesmant problem*[?, ?].

Another characteristic of eusocial creatures – and the focus of our own investigation – is the separation of groups within the colony into differing *castes* that exhibit specialized behaviour, making them more fit for certain types of jobs over others of their colony[?]. Ants in particular are often divided into up to four differing casts: Queens, Minor Workers (Workers), Major Workers (Soldiers) and Drones[?, ?]. Minor workers typically make up [SOME NUMBER]% of the colony, whereas major works usually make up less, often [THE OTHER NUMBER]% of the colony. Our experiment is interested in the area of finding the ratio of minor to major woker ants that has the most positive impact on an ant colony's ability to thrive within a changing environment.

A number of past studies have examined the way that ant colonies search their surrounding areas to locate and retrieve food [?, ?]. Often the these studies focus on simulating ant colonies to apply the emergent behaviour that they exhibit to solve abstracted technical problems [?, ?], with a smaller number of past works focusing on simulating ant colony behaviour as it is seen in nature [?]

The 2004 work by Vittori et al[?] examined the way that ants navigated their environment, using trails of depositied pheromones which attracted other ants. This work in particular was of interest to us, as it evaluated the results of the model by comparing them to real ants in a number of experiments.

Whereas this [?] introduces the concept of a dual-pheromone system, where one set of pheromone leads away, one toward

[?] discusses the benefits of simulating the ant's return path using pheromones or simply having the ants return directly

TODO: Cite one other thing here, giving it another piece of information

These pieces of information inspired us to do stuff like the other stuff

2 Methodology

2.1 System Description

At the highest level our ABM consists of one agent, Ants, and an environment that contains their colony, food and then the pheromones that the ants leave behind. We have modelled two types of ants, major workers and minor workers. These are called workers, for major workers, and scouts, minor workers, in this project's code and some of the diagrams.

The modelling of our agent

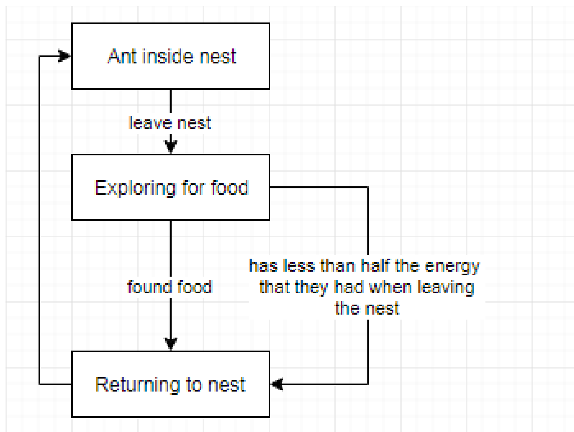

Figure 1: High Level State Diagram for the Ant

The system aims to simulate colonies of ants as they forage for food in a 2d environment. Each colony of ants exists as a single spawn point out of which ants leave to look for food. Each tile contains a value for the strength of food pheromone for each colony. Ants can move from tile to tile to follow pheromone trails towards food. If an ant cannot see a food pheromone trail then they will explore away from the nest for new food sources or food pheromone trails to follow. Ants will reinforce a pheromone trial when they return to the nest with food. To prevent ants being led to depleted food sources, over time these pheromone trails will decay as ants will only reinforce those food pheromone trails that they find food at the end of.

There exists in this simulation two types of ants, the worker and the scout. The worker ant is capable of carrying more food when it forages and the scout ant cannot carry as much but can move at a slightly faster speed. The simulation can then be configured for each colony to have different proportions of worker and scout ants.

Timesteps - every 1 minute Tile Size - 1m x 1m Scout Ant Speed - 0.5 meters per minute (8.3 mms-1) Worker Ant Speed - 0.36 meters per minute (6 mms-1 [source 1])

Assumptions made throughout this model include the assumption that a scout ant moves at a speed which is scaled on the speed we found documented of the worker ant (6 mms-1) [source 1]. Due to the diversity of ant movement speeds, the speed of a scout from one

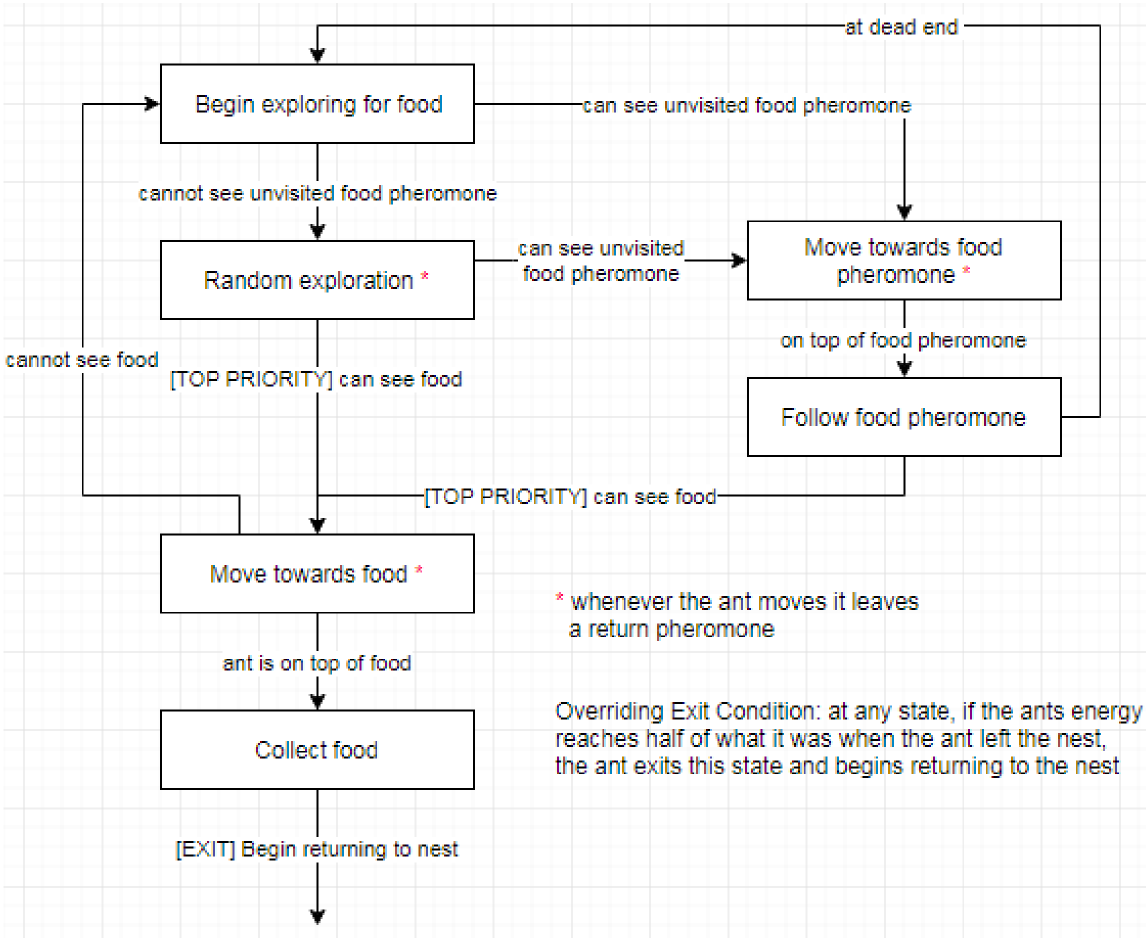

Figure 2: High Level State Diagram for the Ant

species of ant cannot be compared to the speed of a worker from another. By knowing that scout ants move faster however, scaling the worker ant speed gives an approximation of the speed a scout ant of that species would have. Additionally, although ants were modelled to have continuous locations, the environment is grid based and so pheromone trails were located by their tile position. The purpose of this model is that it finds statistical patterns based on the proportion of scout/worker ant populations in each colony, therefore, it is not important that the entire system is modelled in a way that is physically accurate on a ground level, rather that the simulation provides results which are statistically representative of ant colony behaviour.

Another assumption made was to not model ant encounters, this being where two ants move over each other and cause a slowdown. The reasoning for this was that as according to one study ?direct or interaction effects, has a much smaller effect on walking velocity than does body size? [source 2], therefore the speed of an ant is determined entirely by their body size, which is given as the most important factor. The speed of each ant is determined by them being either the larger and slower worker ant, or the faster but smaller scout ant.

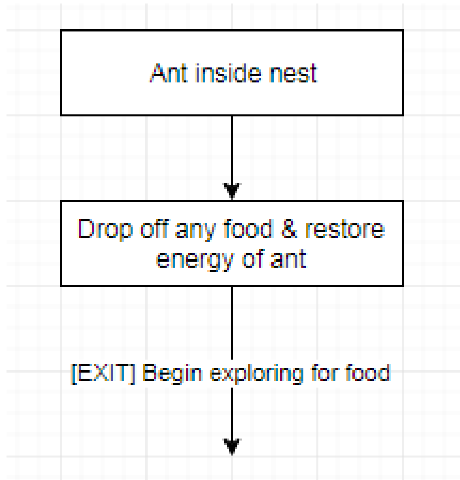

Figure 3: High Level State Diagram for the Ant

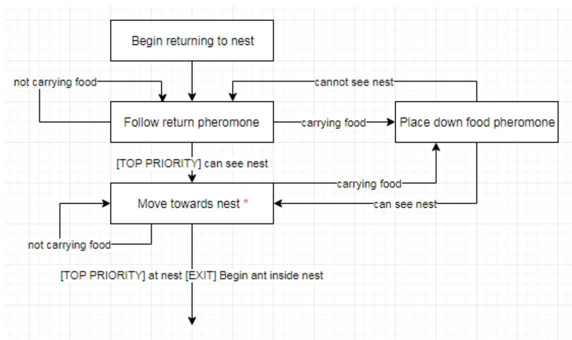

Figure 4: High Level State Diagram for the Ant

2.2 Experimental Setup & Assumptions

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