**Pharaoh’s Ants Foraging Agent-Based Model**

**COM 3001 – Modelling and Simulation of Natural Systems**

**Assignment 2**

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# Introduction

A few paragraphs giving some background on Pharaoh Ants, pheromones, foraging and how it is represented in FLAME. Just reword the background perhaps?

# Literature Review

Many research studies have been undertaken to analyse the behaviour of Pharaoh ants, especially with respect to finding patterns in foraging and the permanence of the pheromone trails they produce. Consequently, by studying these studies, it should be simpler to identify a new research question that could be constructed and analysed by altering the agent-based model already provided.

The paper of Beekman et al [1] experimented with different colony sizes of Pharaoh ants to see if they could find a minimum number of workers that would result in efficient foraging. Due to the fact that the pheromones produced are volatile, their hypothesis was that a certain number of ants would be able to maintain the trail, hence making foraging consistently efficient.

To model the total increase of ants walking to a single food source, the following mean-field equation was used:

This equation indicates that the trail strength increases as more ants use the trail, and ants are less likely to lose a stronger trail.

As expected, the results of this experiment showed that colonies with greater numbers could forage more efficiently. It was found that colonies with 600 workers did not forage in an organised fashion and only when colonies of 700 ants were introduced did the results improve.

This study did not find any revolutionary results that could not have been established by looking at the problem logically and could only speculate as to why these findings occurred. However, it did present some interesting points that could be experimented upon in further research. For example, the respective volatility of the pheromone produced and the different psychological behaviours each would trigger were remarked upon.

The work of Fourcassié and Deneubourg [2] looked at changing the physical and environmental variability’s of the ant. To do this, they altered parameters such as the lighting intensity of the arena, deprivation of food for the ants and changing the amount of time ants had spent in the environment before experimentation was carried out.

Through analysis of the results, one could establish that Pharaoh ants are diurnal, because more ants left the nest when the light was on and the contrary was true when there was no light at all. Food deprivation also increased the number of foragers leaving the nest, due to the fact they were compelled to find food sources quicker.

On an individual level, it was concluded that two different pheromone trails were deposited, one to indicate food sources and one where previously unseen areas had been explored. Additionally, ants showed greater trail laying activity as they were heading away from the nest in comparison to heading back to it.

It seems that this study was very successful, in the sense that it experimented upon a variety of different factors that could affect foraging behaviour. Confirmation of previous studies was established, such as the different pheromone trails but also many new insights were introduced. These included the increased efficiency in lighter conditions and with severe food deprivation as well as the respective trail leaving patterns to and from the nest site.

An interesting study was carried out by Sumpter and Beekman [3] where foraging behaviour was analysed when food sources with differing sugar concentrations were placed into the environment. Their findings were that a colony would exploit a single food source at the same rate, regardless of its concentration. When two food sources of differing concentrations were present, the colony would exploit the higher concentration source more readily. It was found this occurred because the pheromone trail to the weaker food source was constructed slower than that of the higher concentration source, which consequently meant ants were more likely to follow the more intense trail.

Another interesting outcome of this experiment was that when two food sources of equal concentration were placed in the environment, the food source which attracted the most ants initially would be exploited the most overall. This indicates that ants have no notion of choice or weighing up available possibilities.

It can be concluded that this study provided a good insight into foraging behaviour not studied previously. Specifically, new conclusions were made regarding foraging patterns in relation to food source quality and when one or more food sources were available. Additionally, new information was extracted regarding intensity of pheromone trails in relation to food sources.

Finally, the work of Jackson et al [4] looked into how long pheromone trails could be preserved and potential memory ants could preserve in respect to following these trails. It was found that pheromone trails could persist up to 48 hours when colonies of up to 4000 ants were placed in an environment. In relation to trails being re-established after a 24 hour period, it was decided that it would require 1900 ants or 3000 for a 96 hour period. This was in stark contrast to work carried out by Jeanson et al [5] where trails would perish between 8 and 25 minutes. However, the two experiments were relatively dissimilar and could not be comparable.

Other results extracted were that, firstly, ants could only detect the pheromone trail when their antennae were touching the surface, indicating the pheromone produced is very weak and volatile. When ants were deprived of food or were kept in isolation, their foraging efficiency would increase. When brood were absent from the environment, foraging increased by 10%, presumably because the ants could focus on their own nutritional requirements.

In conclusion, this study did find some novel results but also confirmed findings already discovered, for example the food deprivation and isolation theorem was initially declared by Fourcassié and Deneubourg [2]. However, the findings of persistence of trails contradicted that of Jeanson et al [5] and this could be further researched to find a more definitive conclusion. Another original finding was that of manipulating the colony structure, removing the brood increased foraging effectiveness.

# Ant Model Explanation

An explanation of the main aspects of the supplied model – e.g. the agents involved their messages and other key factors. The key parameters, distribution of agent types and so on.

# Implementing a New Research Area

A new research question that could be explored using the model or a suitable adaptation of it. This could include questions relating to what happens if some parameters are changed, if the number of agents in the simulation is changed – how does that affect things, or any other new agents that might be brought into the model. This should include a clear methods description – what has been changed and why.

# Results

A number of simulations should be run for each experiment – at least 10. the length of the simulation should be suitable – if it is too short interesting behaviour might be limited.

# Results Analysis

Here simple statistics should be used – for example you could measure some parameters – e.g. relating to attributes of individual agents, or characteristics/properties of a population of agents etc. Express the results as graphs with error bars or other means to display the spread of results.

# Conclusions

The best way to do this is to define some hypotheses and to test them – can you accept or reject them to some suitable level of significance. Again a well argued statistical analysis is needed.

# References

[1] Beekman M, Sumpter D.J.T, Ratnieks F.L.W (2001). *Phase transition between disordered and ordered foraging in Pharaoh's ants*. Proc. Natl Acad. Sci. USA. 98, 9703–9706.

[2] Fourcassié, V. & Deneubourg, J. L. (1994). *The dynamics of collective exploration and trail-formation in Monomorium pharaonis: experiments and model*. *Physiol. Entomol.* **19**, 291−300

[3] Sumpter D.J.T, Beekman M. (2003). *From nonlinearity to optimality: pheromone trail foraging by ants*. Anim. Behav. 66, 273–280.

[4] Jackson DE, Martin SJ, Holcombe M, Ratnieks FLW. (2006). *Longevity and detection of persistent foraging trails in Pharaoh's ants*, *Monomorium pharaonis*. *Anim Behav* **71:**351–359

[5] Jeanson, R., Ratnieks, F. L. W. & Deneubourg, J. L. (2003). *Pheromone trail decay rates on different substrates in the Pharaoh’s ant, Monomorium pharaonis*. Physiological Entomology, 28

# Group Performance

A list of the contributions of each member of the group – their role – e.g. group leader (if there was one), statistical boffin, programmer, project planning, scientific literature research etc.

A signed statement as to how many hours each member contributed to the project.