Scrutiny of
Häger, Alvin, and Adam Torkkeli-Johansson. "Simulated evolution of food foraging strategies of army ants."

By David Östling
dostl@kth.se
DA2210

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1 Summary

This scrutiny was conducted in order interpret a master thesis about the evolution of food foraging strategies of army ants [2]. The study was heavily based on the fact that ants use *pheromone (a type of semiochemical that triggers a response in the ant's brain [1])* trails to track food. What is notable about this gathering technique is that it generates a large set of different dynamic foraging patterns. In this study these were then investigated *(used as an input)* and compared to one another by using a previously defined algorithmic model [3, 4] *(a computer program which when given an input returns an output [5, 18])* in order to single out what behavioral parameters *(returned as an output)* lead to optimal food-finding patterns. Do note here that the model even takes the competition of other ant colonies into consideration. For the purpose of the study, the behavioral parameters were divided into three different groups; *small and common, large and scarce* and a *combination of both*. In order to determine what these optimal behavioral parameters actually were the thesis implemented an evolutionary search algorithm; a program which went through all parameters and compared them. The results showed that finding optimal parameters and their corresponding patterns was heavily based on specific scenarios. One such scenario would be that the results differed when another ant colony was present. However, the thesis concluded that the evolution of foraging patterns had seen greater evolutionary success for the *small and common* category when compared to its *large and scarce* counterpart. As a result of this conclusion, the authors stated that this research could apply to both natural- and computer science where their some examples were optimization algorithms *(algorithms used to find the optimal solution(s) to a given problem [19]; computer science)* and ant foraging techniques *(natural science)* [2].

2 Scientific considerations

The thesis was mainly written from a *realistic* perspective whereas the goal of science is to describe reality as it is *(what is observable)*; determining which ant foraging patterns have seen the most optimal evolution is clearly observable. However, one could argue that the chemical reaction in the ant's brain from the pheromone [1] is a social response/feeling which in itself could be rendered as a non-observable instance from an *anti-realistic* perspective [5]. The term *anti-realism* is equivalent to regular *realism* but with the addition that nothing can be said about the non-observable part of reality [5]. As a result, the thesis would in a way contradict the *anti-realistic* perspective by treating the social response triggered by the pheromone as a guideline for the study rather than treating it as pure fiction. Although, there is another type of anti-realism called *agnosticism* which could also be relevant in this case. When the ants are exposed to the semiochemical and the social response triggers it might pose as a description of reality and as a description of how the ants work when foraging, although it might not be true. As a result, this uncertainty would from an *anti-realistic, agnostic* perspective reduce the *accuracy* of the study as it is heavily based on the non-observable pheromone response. Another thing to take into consideration here is the two philosophical disciplines; *ontology* and *epistemology* [5]. Since the ants are indeed observable and do exist the *ontology* discipline is fulfilled. Moreover, when it comes to the *epistemology* discipline the thesis gives a great description of how the knowledge about the ants can be retrieved, namely the previously defined algorithmic model [3, 4] which is heavily discussed and applied in the study.

In a way, the thesis could be considered a type of *"testing out research"* as it stands by a *null hypothesis* [5]. This signifies that the thesis is trying to overthrow the previously proposed generalization about ant foraging patterns and attempts to fill in the knowledge gap present in this area of study. As the thesis also brings information that could potentially render the previous discoveries of ant foraging patterns inadequate further signifies that the thesis stands by a null hypothesis. Furthermore, the arguments in the thesis are greatly structured and backed up with both scientific data returned from the model as well as pictures describing how the model works. One such image can be seen below *(view figure 1)* and it functions as an exceptional tool of understanding the model used; even for those unfamiliar with Computer Science. As a result, the thesis becomes easier to understand, read- and even reproduce. Moreover, along with the great structuring, the data in the study is very well presented as well which increases the overall *openness* [5] of the thesis. Not only does the shared data pose as a good standard for reproducibility but also as a sort of permission of criticism from the authors. As they do share- and present that data in this manor they open themselves to criticism from others which further supports the increase of *openness*. Along with this, the majority of the content described within the thesis is heavily backed up with trustworthy sources *(most of them peer reviewed, all of them well cited)* and at first glance everything seems to be explained on a satisfactory level. Not only does this apply to the argumentation but also to the definitions used in the study. One such example would be the term *foraging* and how the authors defined it for this particular study. Without a doubt the authors seem very knowledgeable about the topic and present their thoughts in an adequate manor.

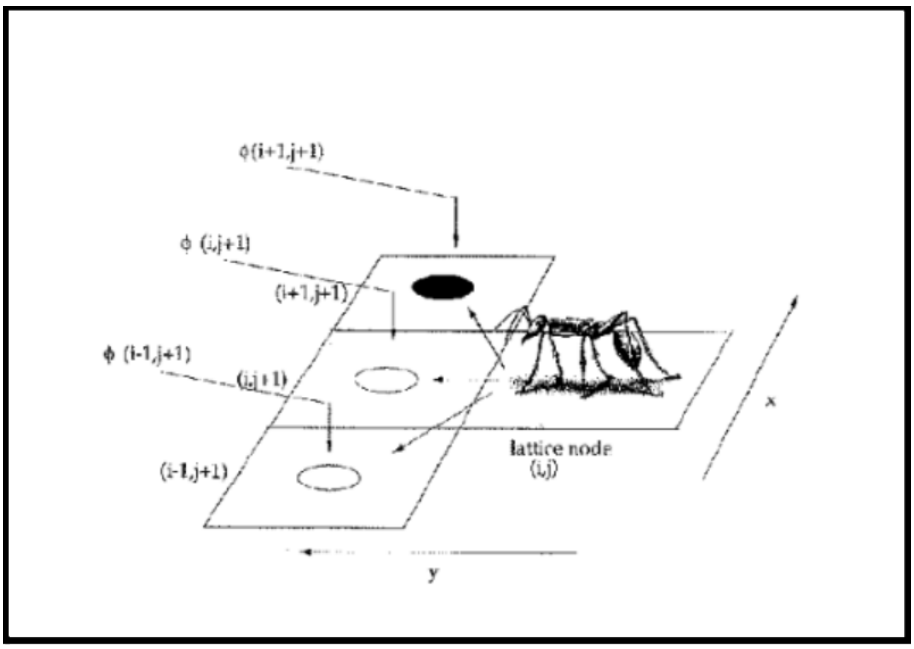

Figure 1: Description of ant movement in the used foraging model [5]

When it comes to ethical issues one such would be that most of the graphs provided within the study are dependent on *"an example of one"* simulation [2]. Undoubtedly, it is not recommended to base any results from one simulation alone as it does not really conclude anything. On the contrary, the ethical part of the issue lies in what they *could* supposedly might have hidden. Similarly to the famous *Robert Millikan experiment* [5, 7] the authors could have simply removed the simulations that did not correlate with their desired outputs from the experiment. However, this does not necessarily have to be the case, it could simply come down to the authors being lazy or them believing it would be sufficient to opt with one example alone for some of the graphs. Although if this were to actually have been the case it would have undoubtedly saved them a lot of time and work. If the authors already had their minds set on what they would write even before beginning the simulations it would be easier for them to go with what they had in mind at first and try to alter the results of the experiments in their favor. This way they could write the thesis much more efficiently and simplify the process of answering their research questions. Nonetheless, do note that this is not intended to be an accusation of any sort, it is simply an analysis of a possible ethical issue.

One of the research questions were whether or not the foraging patterns would differ if another ant colony would be present [2]. The results showed that this was indeed the case, it is *true* that they did differ. Consequently, this fact could be considered a type of *coherence truth* [5, 6] as it is logically linked to the previous statement about how ants forage when another colony is not present. Additionally, the results of the first test (when another colony was not present) could be labeled a type of *correspondence truth* [5, 6]

as it simply responds to the reality of the test. However one could argue that this could also be a type of *coherence truth* as it follows from the algorithmic model. Nevertheless, another research question was what evolved optimal ant behavioral parameters along with what food foraging patterns would differ from each other and which type of food foraging patterns had seen greater evolutionary success *(small and common or large and scarce)*. By implementing the model [3, 4] the results showed that the food foraging patterns for *small and common* category had seen the greatest evolutionary success. As the result follows from the model used this could be considered a type of *coherence truth* [5, 6] as well as it is logically linked to the algorithmic model used.

3 Suggestions

To begin with, while a lot is great in terms of reproducibility there is still room for improvement here. One such example would be that some of the explanations of the mathematical formulas used in the thesis could benefit from going into further detail. This way the reproducibility for the thesis would greatly increase as the process of trying to understand how the formulas work and exactly what they return would be minimized (perhaps the authors of the thesis could even have used *confidence intervals* [5] to further strengthen the *accuracy* of their results). Although it is important to note here that the explanations present as of now are still satisfactory for reproducing the study. It should be noted though that they could definitely be improved in order to increase the effectiveness of a potential reproduction (especially for those unfamiliar with computer science and optimization algorithms). As for the results there are some complications to be found here as well. As stated earlier some of the graphs are based upon *"one example of a simulation"*. This greatly reduces the overall *accuracy* and *openness* (if they choose not to display certain simulations they limit their openness) of the results and it would be a lot better if they could display more simulation examples in the corresponding graphs.

Another thing that the thesis does really well is to support the argumentation with instructional images and graphs of the results found. This makes it easier not only for the reader to understand what is presented by the authors but also why and how they applied the model and search algorithm provided within the study. Furthermore, this makes the relevancy of the results easier to understand as well. In this case, as there are many abstract concepts present in the thesis it could probably benefit from having even more of these types of explanatory images. As a result of this, the reproducibility would also see gains in terms of efficiency. What is more, the overall content of the thesis is sometimes displayed rather unnatural. Having one entire page dedicated to a half-sentence is an example of this. There are also several occasions when the thesis could have benefited from simply starting a new section on a new page instead of forcing it to fit on the previous one. This could result in a better reading experience overall as it can be a bit confusing at times with these structural anomalies. .

While the model used is well adapted for the purpose of the study it was composed in 1983 and 1989 [3, 4] respectively. Here it should be noted that in the criteria for the master thesis it is stated that *"Connections to current research and development is missing or deficient"* [12]. The term *"deficient"* is most relevant in this case, the question is if this can really be considered a current research connection when the guideline for the entire thesis is based on publications from the 20th century. However, a lot of the other sources are much more up to date and are used in such a way that they support the model on a satisfactory level. Hence, it is obvious that they have made connections to current research as requested by the criteria but they could be a bit deficient. Even so there is a clear reason as to why they did not use a more up to date model; there simply does not seem to be many alternatives to the model they opted with. Due to this, an example of an alternative would be to use even more sources to strengthen the relevancy of the aged model rather than attempting to improve- or create an entirely new model. This would most likely be the most time efficient solution and as a result the overall *accuracy* of the thesis would also see an improvement causing the thesis to further fit the criteria for a master thesis [12].

If this thesis [2] would have been conducted as of today a lot of new research has been done in the respective field which could really benefit the study. Not only does the new research correspond to the computer science field but also natural science; particularly the semiochemical pheromone which has posed as a key resource for the thesis. This could not only improve the current *accuracy* of the thesis but also broaden the scope of ants, the possibilities are vast. Perhaps if other ant species were included in the study as well it could serve a more important role than it does today. On the contrary the thesis could (if both the authors were very experienced with programming and optimization algorithms) benefit from improving the efficiency of the used model [3]. By updating it to today's standards of optimisation algorithms it could result in an overall greater accuracy for the results as well as a faster runtime *(the rate at which the algorithm can run [11])* for the algorithmic model. It should be noted that this could be very time consuming even if the authors are familiar with the programming required to improve the model. But if they were to improve it there is a lot of new research to be found in this field as well. Finally, the natural science field regarding general ant foraging (apart from pheromone by itself) has also seen more recent discoveries which could be applied in the thesis. A few (but note that there are many more) examples from each field can be found in the list below.

Examples of newer relevant sources:

- Pheromone & Foraging [8, 9, 10]
- Computer Science & Optimization Algorithms [13, 14, 15]
- Natural Science & Related Fields [9 ,10, 16, 17]

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