MATLAB Fall 2014 – Research Plan

Dessert Ant Adaptive Navigation

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GitHub: `https://github.com/dowerner/Desert_Ant_Adaptive_Orientation`

Project Title: Dessert Ant Adaptive Navigation

General Introduction

The Desert Ant (Cataglyphis) is an interesting creature. It lives in the desert where conditions are very harsh. Since the ant will die if it remains outside its nest for too long it will die because of the hot sand it crawls on. It is vital for the ants survival that it has a sophisticated way to navigate through the pans of sand that make out most of its habitat. Since the early 20th century biologists have been fascinated by this ant and its navigation through the desert. Recently there has been speculation about the methods that are utilized by these ants to navigate between sources of food and their nest. If we could reproduce the path-pattern observed by real ants with a model we would be able to predict how they would react if something would change in their ecosystem. We will base our work upon an essay written by R. Wehner with the title "Desert ant navigation: how miniature brains solve complex tasks". In this essay he suggests 3 methods of navigation which the ants can use, namely path integration, pheromones and visual landmark recognition. In his final conclusion he considers all 3 methods important and assumes that the ant has a way of adopting the priority of each mechanism according to the current situation. In Previous years a group called gordonteam already implemented a model based on the before mentioned article. In the report they noted that their path integration did not work and that they were not able to combine all 3 methods. Our plan is to extend upon their work and fix the problems as well as to bind all 3 methods together. Furthermore we want to implement a memory system along with a learning machine which will allow the ant to dynamically adapt to an environment.

The Model

For our simulation we will use an agent based model where every agent will be representing an ant. To be able to compare our model with the real world data we have to keep track of several different variables:

nestLocation: This is a 2D vector which indicates the position of the nest inside a sand pan.

foodSourceLocation(s): These 2D vectors symbolize the location of a food source which the ant will have to travel to. It should be possible to implement an ephemeral (non-renewable) food source so the ant has to look for a new one if the first does not yield food anymore.

pheromoneParticles: Objects that represent pheromone particles with a specific lifetime. These pheromones can be produced by ants.

ants: The agents themselves who contain their position data and other information to track the simulation.

landmarks: Objects that symbolize visual orientation points for the ants.

Fundamental Questions

At the end of this project we want to have a model which is able to simulate realistic desert ant behavior in a variable setup. If this should not be possible we want to be able to tell which factors make such a model difficult to implement and how it could probably be achieved after all. Core questions will be:

- Is the model accurate, therefore do the walking patterns that we've simulated match the empirical ones?
- Do they match in length?
- Do they match in directions?
- Do they match in distribution?
- How does the memory effect the path pattern?
- Also, do the decisions which the ants learned make sense?
- Are we able to predict what happens if we alter the environment? (depends on the question beforehand)
- Can the ants survive if we rid the environment completely of any landmarks?
- Can the ants survive if the landmarks constantly change?
- Can the ants survive if temperature would increase (pheromones will last shorter, ants have to come back to the nest faster)?

As indicators of survival and the other parameters we can use the success-funciton as well as the agent properties that belong to our model.

Expected Results

The article we base our work upon does state that its conditions might be flawed in some ways. The provided experimental data however looks promising so we expect:

- That the patterns should be produced in a similar way as in the experiments. Therefore:
- That the lengths of the paths match with the real ones.

- That the directions of the paths are chosen as in reality.
- That the ants distribute themselves reasonable among the food sources.
- That the implemented memory causes the ants to extend the search radius once a food source has run out. This means the ant should look for new sources starting from the old source.
- That the ants can switch to another method of navigation should the need arise?
- That the ants behavior becomes predictable. Therefore:
- That ants can survive if landmark navigation is impossible by using the other 2 methods.
- That ants can survive even if the conditions of their environment gets harsher provided they have enough resources in their proximity.

References

For this project we will use the following references:

- "Desert ant navigation: how miniature brains solve complex tasks"by R. Wehner
- Path integration in desert ants, Cataglyphis fortis"by M. Müller and R. Wehner

We will start off our project on the work of *gordonteam*. They have worked on the subject and came up with a model which does not take into account the afore mentioned changes we intend to implement. Also we will try to fix their path integrator which they could not get working during the project.
project of gordonteam: `https://github.com/msssm/desert_ant_behavior_gordonteam`

Research Methods

Agent-Based Model