Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Lecture with Computer Exercises:
Modelling and Simulating Social Systems with MATLAB

Project Report

Dessert ant Adaptive orientation of dessert ants (Cataglyphis)

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Agreement for free-download

We hereby agree to make our source code for this project freely available for download from the web pages of the SOMS chair. Furthermore, we assure that all source code is written by ourselves and is not violating any copyright restrictions.

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1 Abstract

The Desert Ant (Cataglyphis) is an interesting creature. It lives in the desert where conditions are very harsh. Being to long outside of its nest the ant will die due to the ambient heat, therefore it is more than vital for the ant's 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 essays written by R. Wehner [1],[2], [3]. In his work he suggests 3 methods of navigation which the ants can use, namely pathintegration, 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[4] 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.

2 Individual contributions

2.1 Orientation

As mentioned the desert ant's main means of orientation are:

- pathintegration
- local landmark orientation
- pheromones

The pathintegration and the local landmark orientation are primarily used in order to get back to the nest from a food source, whereas the orientation by pheromones is mainly used to find a prelocated food source.

in an educated guess check. Email an R. Wehner.

2.1.1 Pathintegration

No matter the zig-zag way out of its nest, the ant is able to return in a more or less straight line. This remarkable ability is reached by pathintegration. The ant iteratively computes the mean of all its turning angles executed and is therefore always aware in which direction its nest is located. These calculations are executed with imperfections which accumulate with growing distance. In extreme cases pathintegration causes the ant to miss its nest and other means of orientation are necessary. In Wehner1988[2][1] the following formulas have been derived, they take into account the rough approximation of the ants pathintegration.

$$\begin{aligned} \varphi_{n+1} =& \varphi + k \cdot \frac{(180^\circ + \delta) \cdot (180^\circ - \delta) \cdot \delta}{l_n} \\ l_{n+1} =& l_n + 1 - \frac{\delta}{90^\circ} \end{aligned}$$

l_n : current distance (in unitlength) to the nest
φ_n : current angle that points backwards to the nest
k : normalization factor
δ : executed angle

l and φ are constantly updated and together they form the *global vector*.

damit nicht grösser als 90

2.1.2 Local landmark orientation

The ants can make use of landmark orientations. They can recreate a certain route by memorizing given landmarks in the correct sequence.

[1] on page 5288

2.1.3 Pheromone orientation

Having found a food source the secretion becomes more intense. Other ants are attracted to the pheromones of their conspecifics and are therefore guided to the foodsource and thereby pheromone trace is further augmented. Once the foodsource is depleted the ants fan out and the pheromone evaporates exponentially GordonTeam2008[4] [2].

$$I(t) = I(t - \Delta t)\exp(\frac{\log(\frac{1}{2})\Delta t}{t_c})\Delta t$$

2.1.4 Combination

As mentioned the pheromone orientation is used as a mean to find a food source not a mean to return back to their nest.It is not that the various means of orientations are combined in a weighted fashion. Given certain criteria the different means are used separately.

Nochmals klären ob das Stimmt.

The results gained R. Wehner's experiments indicate that ants use predominantly pathintegration, but if available using local landmarks is more preferable to using the global vector-navigation via pathintegration. It has been concluded that the ant transiently inhibits the global vector when being in familiar territory. The global vector only reemerges after the local vector ceases. Whilst navigating via the local vector the global vector is continuously updated.

Algorithm `ReturnToMyNest()`

```
while not at nest do
    secrete pheromones;
    execute global vector;
    update global vector;
    if local vector recognised then
        while local vector > 0 do
            execute local vector;
            update local vector;
            update global vector;
        end
    end
end
return
```

Algorithm 1: Returning to the nest

[2] on page 9

3 Introduction and Motivations

4 Description of the Model

5 Implementation

```
function angle = vector2angle(v)

if abs(v(1))<10^(-5)
    %v(1)=sign(v(1))*10^(-4);
else

end
angle = atan(v(2)/v(1));
if v(1) < 0
    angle = angle+pi;
 end
end
```

Listing 1: Beispiel

6 Simulation Results and Discussion

7 Summary and Outlook

8 References

Literatur

[1] R. Wehner. *Karl von Frisch lectures*. Springer, July 2003.

[2] R. Wehner et al. *Neurobioligy Vol. 85*. Proc. Natl. Acad. Sci. USA, July 1988.

[3] R. Wehner et al. *Letters to Nature Vol.394*. Macmillan, July 1998.

[4] V.Megaro, E.Rudel. *MSSSM - Thesis GordonTeam*. ETH, 2008.