Artificial Ants Searching Their Way Out – Basic Study on Pheromones and How Ants Communicate

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Abstract

Artificial Intelligence (AI) is one of the most promising fields in Computer Science. It is a so vast field that many specialties were created within the field, each one trying to solve a different problem or modeling a specific behavior of nature. One recent area of study is based on the behavior of ants and the tasks they accomplish when they interact. It is very interesting that even without a central command and not being able to communicate directly, they can perform huge tasks as effectively searching and transporting food, and using an optimal path between the nest and the food source. This paper intends to introduce the concept of how ants interact to achieve a common goal, and to implement a simulation program that proposes a simple problem to our digital ants: how to find the way out of a given box and make it an optimal solution.

1. The Real World ants

2. Putting Ants to Work – The Proposed Problem

The proposed problem for our digital ants is very similar to the fundamental task of searching for food, but instead, they have to find their way out of a box. Ants are inserted in a digital environment through an input hole, unknowing the direction of the exit hole. Once inserted into the box through this hole, they cannot use the input hole as an exit. The simulated environment is a rectangular box delimited by four walls. Ants are limited to the plane formed by the walls and can only walk using the two dimensional space formed by this rectangle. Once ants are put into the box, they do not know the location of the exit, and will walk in a random pattern designated "lost walk". If by coincidence they find the exit hole, they will get out of the box.
Ants cannot communicate directly with each other; their only way to communicate is by the use of pheromones. Also, they do not have memory, and they only have a limited sensorial range to detect nearby pheromones.

3. Pheromones and the Conceptual Solution

To find the exit hole, ants will use pheromones to communicate where the exit is. Pheromones evaporate when released, in other words, they have a determined duration (expiration) that they

are effective represented here by "e". At any given time, it is possible to calculate the Pheromone power using the following formula:

$$\phi_i = \frac{e-(t_i - t_0)}{e};$$

Φ_i represents the pheromone power at a given time "t_i". The pheromone has max power when $\Phi=1$, and it has no effect when $\Phi \leq 0$. Pheromone power is calculated for each instant "t_i" of time since it was inserted into the environment at instant "t_0".

Ants will have the help of "searching ants" to mark a pheromone trail to the exit. Ants will deposit pheromones in different intensities, each one for a given situation. When they are in searching mode, their pheromone will have an expiration time equals "e". When "lost" ants find a pheromone trail, they will start following that trail, and will start releasing pheromones by themselves. Pheromones released by ants not in "search" mode (e_l), but following a trail will have a shorter life span, determined by a fraction of a regular pheromone:

$$e_l = \frac{e}{k}$$

As a regular ant, "searching" ants do not previously know the location of the exit hole, but they will have a different walking pattern, designated "searching walk". When walking in this pattern, they will make turns with a narrower turn range, meaning that they will probably follow one direction from the input hole and keep walking until they hit a wall or find the exit hole. They will interpret the act of hitting a wall as a failure to accomplish their goal, and to avoid making other ants to follow a trail that doesn't lead to a solution, they will destroy their own trail. In the other hand, if they do find the exit hole, instead of leaving the box right away, they will follow their own trail back and reinforce that trail. The reinforcement is accomplished by extending the expiration property of the pheromone by using the following rule:

$$e_r = e.k$$

With an extended durability, the reinforced pheromone will present an increased probability for other "lost" ants to find that trail and therefore finding the exit hole.

3. Some Information on the Ant Box Simulator

References