Original Bias Factors

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Overview

In this document, I outline in detail the series of bias factors which govern ants' behaviours in the original simulation model for the FIT2082 research project linked *here*. These form the rules which underlie the movements of ants in our simulation model, since motion is chosen according to an ant's preferences or *biases*. Not every possible location is equally-appealing to an ant, and this allows us to distinguish between them by behaviour.

Notation

Let's represent the state of an ant as a triple

$$\mathcal{A} = (a, d, h)$$

where $a \in \mathbb{R}^*$ is the age of the ant in days, $d \in \{-1, 0, 1\}^2$ is the direction the ant is facing, and $h \in \mathbb{R}^*$ is its "holdness" attribute, determining the strength of the ant's preference to continue moving in an approximately-fixed direction.

By default, ants have fixed $h = 10$, and an initial age which is determined to mimic the experimental conditions in the study (Mersch, Crespi, and Keller 2013).

Behaviour

At each step, there is a 20% chance that an ant will remain stationary. Otherwise, it considers a sequence of cardinal and intercardinal directions $d_1, ...d_8 \in \{-1, 0, 1\}^2$ with associated weightings $w_1, ..., w_8 \in \mathbb{R}^*$, where w_i is initially 0 if following d_i leads to an obstruction, and 1 otherwise. We apply the following to each ant $\mathcal{A} = (a, d, h)$.

Hold-direction bias

First, we apply

$$w_i \mapsto \frac{w_i h}{1 + ||d_i - d||_2}$$

which is the hold-direction bias. This serves to have ants prefer to move in roughly-straight lines; about one third of the time, a small "wobble" is added to this step.

General Pheromone bias

We compute

$$b = \frac{1}{5} \exp\left(-\frac{a}{50}\right)$$

If d_i is not obstructed and leads to c general pheromones, then we apply the following

$$w_i \mapsto w_i + bc$$

to form the general pheromone bias.

Brood Pheromone bias

We compute

$$b = \left(A + \frac{B(x-D)}{E}\right) \exp\left(-\frac{C(x-D)}{E}\right)$$

with

$$A = 3, B = 1.65, C = 0.07, D = -4.8, E = 2.33$$

calibrated to obtain a peak factor around roughly the age of 25 days, followed by decay, as interpreted from the real-world study by Mersch, Crespi, and Keller 2013. Once again, if d_i is not obstructed and leads to c brood pheromones, then we apply the following

$$w_i \mapsto w_i + bc$$

where c denotes the brood pheromone count in the associated location, is the brood pheromone bias.

Exploration bias

Suppose that d_i leads to a location with less than 3 general pheromones and less than 3 brood pheromones, or that d_i leads to a location with at least 3 foraging pheromones. In this case, we apply

$$w_i \mapsto 0.065 \left(\tanh\left(\frac{a-130}{10}\right) + 2\right) w_i$$

which forms the exploration bias.

Food/Foraging bias

Finally, for every tile in a radius of 5 from the ant's current location which is not contained within the nest area, we apply

$$w_i \mapsto w_i + 15c$$

where c denotes the amount of food at that location and where d_i corresponds to the general direction of that food.

Selection of Direction

A direction d_i is chosen at random, where the chance of selection d_i is given by

$$p_i = \frac{w_i}{\sum_i w_i}$$

for each $1 \leq i \leq 8$, under the assumption that at least one direction is not obstructed.

References

[1] Danielle P. Mersch, Alessandro Crespi, and Laurent Keller. "Tracking Individuals Shows Spatial Fidelity Is a Key Regulator of Ant Social Organization". In: *Science* 340.6136 (2013), pp. 1090–1093. ISSN: 0036-8075. DOI: 10.1126/science.1234316. eprint: https://science.sciencemag.org/content/340/6136/1090.full.pdf. URL: https://science.sciencemag.org/content/340/6136/1090.