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 $h \cancel{= 10} = 40$, 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~~

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

~~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.~~

The new hold-direction bias is simpler. A turn of strictly-less than ninety degrees has its associated weight w_i mapped to $w_i h$, and a turn of ninety degrees has its associated weight mapped to $\frac{1}{2} w_i h$. Greater turns than these are associated with weight zero and won't be selected.

If an ant moves diagonally into a corner, this could cause it to get stuck indefinitely, however. To remedy this, we can instead map w_i to $\frac{1}{100} w_i h$ so that there is still some positive weighting to the steeper changes in direction.

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.