How Pheromone Trails Effect Navigation within an Ant Colony

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1 Equations

1. ant navigation when no pheromone present
2. probability ant follows pheromone trail (home trail 99%, food trail 80-ish%)
3. pheromone concentration depletion
$$C_i[k+1] = C_i[k](\kappa)$$
4. the ability of ants to detect and respond to pheromone
$$f(C) = \left(1 + \frac{C}{1+\rho C}\right)^{\zeta}$$

2 Variables

1. $C(x, y)$ pheremone concentration at (x, y)
2. ants emit pheromone at given rate $\eta = 0.07$
3. pheromone evaporates at rate $\kappa = 0.015$
4. the mean density of ants ρ_0. (number of ants present)
5. average pheromonal field $\sigma_0 = \rho_0\eta/\kappa$
6. ordered behavior (non-random walk) sets in when $\sigma_0 f'(\sigma_0)/f(\sigma_0) - 1/\beta > 0$

3 Modelling foraging ants in a dynamic and confined environemtn

https://www-sciencedirect-com.colorado.idm.oclc.org/science/article/pii/S030326471000239X?via%3Dihul
Notes:

- half life of pheremone on plastic is about nine minutes and about 3 minutes on paper

4 Random Walk

$\theta = \pi/3$
CRW theta $= \pi/2$

$$\triangle X_{i+1} = v\big[\ \cos(\theta_i + \theta_i^{\text{CRW}})\big]$$
$$\triangle Y_{i+1} = v\big[\ \sin(\theta_i + \theta_i^{\text{CRW}})\big]$$

5 Biased Random Walk

$w =?$
$\theta = \pi/3$
CRW theta $= \pi/2$
BRW theta $= \pi/3$
$\theta_0 \in [\frac{2\pi}{3}, \frac{\pi}{2}, \frac{\pi}{3}]$

$$\triangle X_{i+1} = v\big[w\cos(\theta_0 + \theta_i^{\text{BRW}}) + (1-w)\cos(\theta_i + \theta_i^{\text{CRW}})\big]$$
$$\triangle Y_{i+1} = v\big[w\sin(\theta_0 + \theta_i^{\text{BRW}}) + (1-w)\sin(\theta_i + \theta_i^{\text{CRW}})\big]$$

$\beta = \pi/3$
$\varphi =$ ant height

Area of Ant $= x^2 + y^2 \leq \left(\frac{\text{ant height}}{2}\right)^2$ (in our case, the ant is 10x10 pixels so)
$= x^2 + y^2 \leq 25$

Sensing area

$$2\int_{-\frac{3}{\pi}y}^{\frac{3}{\pi}y} \sqrt{-x^2+100} - \sqrt{-x^2-25}\,dx$$

where (x, y) is the current position of the ant

$y = \sqrt{-x^2 + 100}$

$y = \frac{\pi}{3}x$

$y = -\frac{\pi}{3}x$

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if pheremone present

  if max(pheremone_concentration) == A
    biased_random_walk(bias = 2pi/3)

  else if max(pheremone_concentration) == B
    biased_random_walk(bias = pi/2)

  else if max(pheremone_concentration) == C
    biased_random_walk(bias = pi/3)
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