Hive Simulation

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Outline

Advanced model: Environment simulation

Model overview

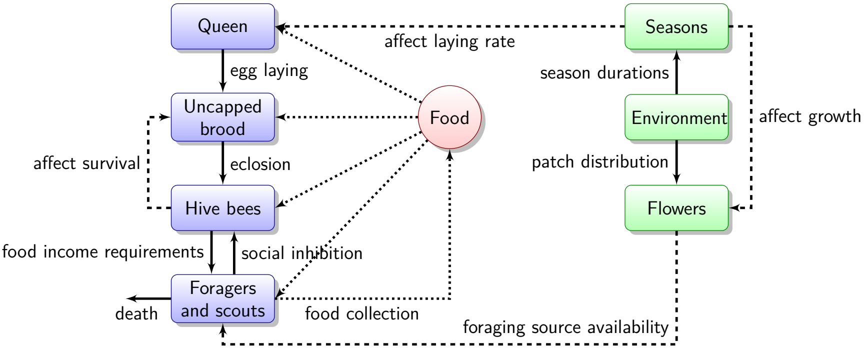

Figure 1: *Honey bee social dynamics and environmental influences covered by our advanced model.*

Agents: Assigning jobs

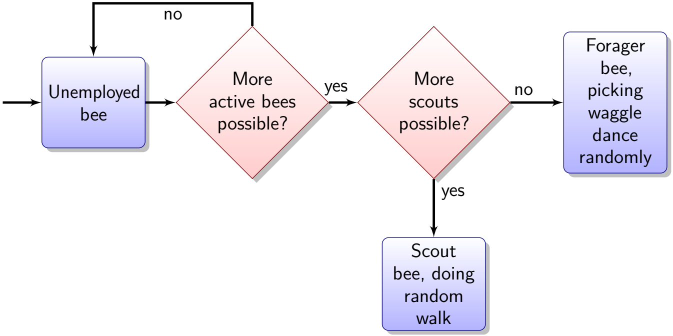

Figure 2: *Assigning jobs to unemployed bees. Scouts and foragers are possible.*

Foragers' distribution across flower patches

- Bees will focus on newly reported and then on the most profitable food sources
- Driving factors for evaluating a patch ($p < q$):
  1. Patch quality (b_w)
  2. Distance from the hive (d_w)
  3. Patch size (A_w)
- Relative evaluation based on what other foraging sources are available

Agents: Scout bees

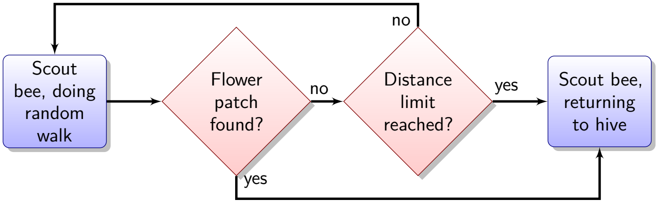

Figure 3: *Scouting behaviour until a flower patch is found or the maximum distance is reached.*

Scouts' random walk

The path a scout bee walks is recorded in a vector of x and y coordinates:

$$\begin{pmatrix} x_0 & x_1 & \dots & x_n \\ y_0 & y_1 & \dots & y_n \end{pmatrix}$$

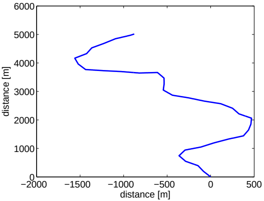

Figure 4: *Example of a random walk executed by a scout bee.*

Agents: Forager bees

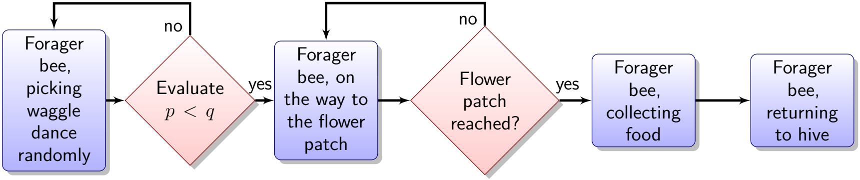

Figure 5: *Foraging behaviour.*

Path optimization

- Bees are able to orientate themselves in the environment with sun positioning [**seeley95**]
- Every second way point is skipped
- Starting- and endpoints are preserved
- Triangle inequality $\Rightarrow L^2$ norm of the distance can only become smaller

$$\begin{pmatrix} x_0 & x_1 & x_2 & x_3 & x_4 & \dots & x_{n-3} & x_{n-2} & x_{n-1} & x_n \\ y_0 & y_1 & y_2 & y_3 & y_4 & \dots & y_{n-3} & y_{n-2} & y_{n-1} & y_n \end{pmatrix}$$

$$\Longrightarrow_{optimization} \begin{pmatrix} x_0 & x_2 & x_4 & \dots & x_{n-4} & x_{n-2} & x_n \\ y_0 & y_2 & y_4 & \dots & y_{n-4} & y_{n-2} & y_n \end{pmatrix}$$

Path optimization

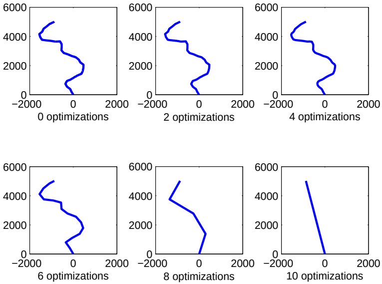

Figure 6: *Example of path optimization used to short cut the path to flower patches.*

Agents: Returning to the hive

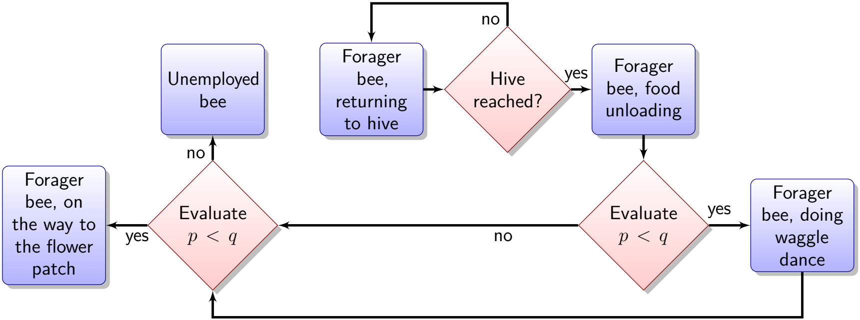

Figure 7: *Forager bee, returning from foraging.*

Agent based model: recorded sample clips

- Day 158, recorded sample with scouts displayed
- Day 158, recorded sample without scouts displayed
- Two different runs, not the same flower patches are being selected

Questions?