

Lecture 14

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Project 2

- For asynchronous updating, let k be the cell that is updated
- Then:

$$s_k(t+1) = \text{sign} \left[h + J_1 \sum_{0 < i_j \neq R_1} s_j(t) + J_2 \sum_{R_1 < i_j < R_2} s_j(t) \right]$$

- Note: for convenience cell k is not included in the R_1 neighborhood
- For all other cells i , $s_i(t+1) = s_i(t)$

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Energy Function

- The energy function is defined by a summation over all the cells, including the one that changed:

$$E\{\mathbf{s}(t)\} = -\frac{1}{2} \sum_i s_i(t) \left[2h + J_1 \sum_{0 < i_j \neq R_1} s_j(t) + J_2 \sum_{R_1 < i_j < R_2} s_j(t) \right]$$

- You need to show that

$$\Delta E = E\{\mathbf{s}(t+1)\} - E\{\mathbf{s}(t)\} \leq 0$$

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Trail Following

- Ants preferentially follow stronger of two trails
 - show no preference for path they used previously
- Ant may double back, because of:
 - decrease of pheromone concentration
 - unattractive orientation

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Probability of Choosing One of Two Branches

- Let C_L and C_R be units of pheromone deposited on left & right branches
- Let P_L and P_R be probabilities of choosing them
- Then:

$$P_L = \frac{(C_L + 6)^2}{(C_L + 6)^2 + (C_R + 6)^2}$$

- Nonlinearity amplifies probability

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Additional Adaptations

- If a source is crowded, ants may return to nest or explore for other sources
- New food sources are preferred if they are near to existing sources
- Foraging trails may rotate systematically around a nest

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Pheromone Evaporation

- Trails can persist from several hours to several months
- Pheromone has mean lifetime of 30-60 min.
- But remains detectable for many times this
- Long persistence of pheromone prevents switching to shorter trail
- Artificial ant colony systems rely more heavily on evaporation

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Resnick's Ants

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Environment

- Nest emits *nest-scent*, which
 - diffuses uniformly
 - decays slowly
 - provides general orientation signal
 - by diffusing around barriers, shows possible paths around barriers
- Trail pheromone
 - emitted by ants carrying food
 - diffuses uniformly
 - decays quickly
- Food detected only by contact

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Resnick Ant Behavior

1. Looking for food:
 - if** trail pheromone weak **then** wander
 - else** move toward increasing concentration
2. Acquiring food:
 - if** at food **then**
 - pick it up, turn around, & begin depositing pheromone
3. Returning to nest:
 - deposit pheromone & decrease amount available
 - move toward increasing nest-scent
4. Depositing food:
 - if** at nest **then**
 - deposit food, stop depositing pheromone, & turn around
5. Repeat forever

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Demonstration of Resnick Ants

[Run Ants.nlogo](#)

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