Real Ants

(especially the black garden ant,
Lasius niger)

Adaptive Significance

- Selects most profitable from array of food sources
- Selects shortest route to it
  - longer paths abandoned within 1–2 hours
- Adjusts amount of exploration to quality of identified sources
- Collective decision making can be as accurate and effective as some vertebrate individuals

Observations on Trail Formation

- Two equal-length paths presented at same time: ants choose one at random
- Sometimes the longer path is initially chosen
- Ants may remain "trapped" on longer path, once established
- Or to a lower quality source, if it's discovered first
- But there may be advantages to sticking to paths
  - easier to follow
  - easier to protect trail & source
  - safer

Process of Trail Formation

1. Trail laying
2. Trail following

Trail Laying

- On discovering food, forager lays chemical trail while returning to nest
  - only ants who have found food deposit pheromone
- Others stimulated to leave nest by:
  - the trail
  - the recruitor exciting nestmates (sometimes)
- In addition to defining trail, pheromone:
  - serves as general orientation signal for ants outside nest
  - serves as arousal signal for ants inside

Additional Complexities

- Some ants begin marking on return from discovering food
- Others on their first return trip to food
- Others not at all, or variable behavior
- Probability of trail laying decreases with number of trips

Frequency of Trail Marking

- Ants modulate frequency of trail marking
- May reflect quality of source
  - hence more exploration if source is poor
- May reflect orientation to nest
  - ants keep track of general direction to nest
  - and of general direction to food source
  - trail laying is less intense if the angle to homeward direction is large

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

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

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

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

Resnick's Ants

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

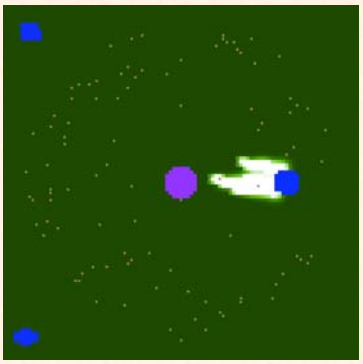
Resnick Ant Behavior

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

Demonstration of Resnick Ants

Run ResnickAnts.slogo

Exploitation of Multiple Food Sources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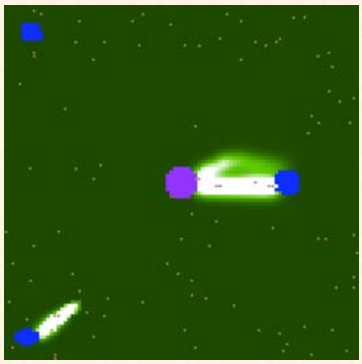
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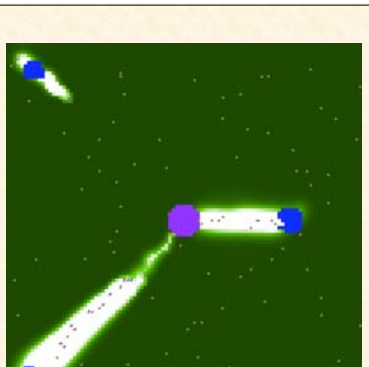
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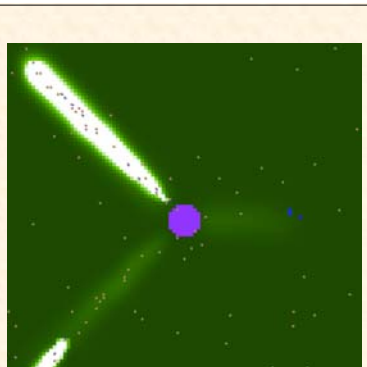
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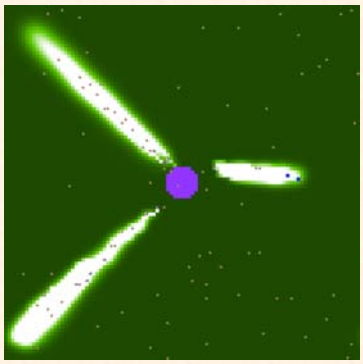
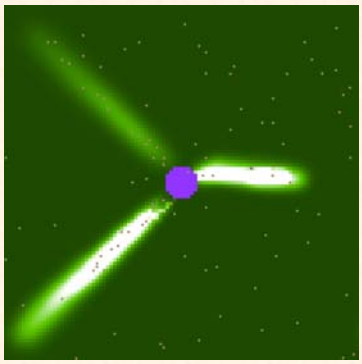
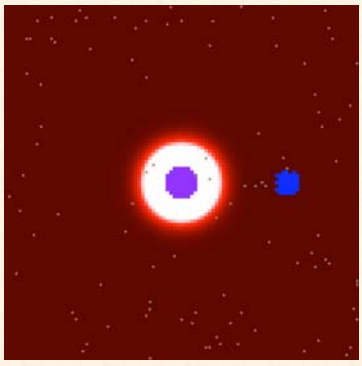
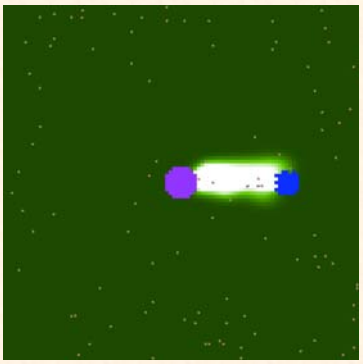




Insertion of Barrier





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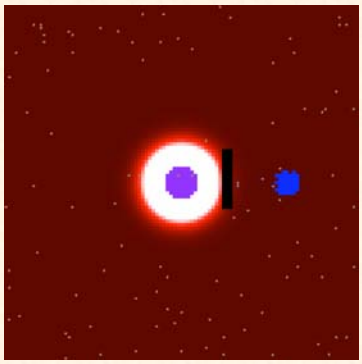

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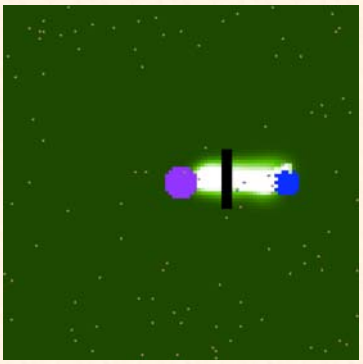

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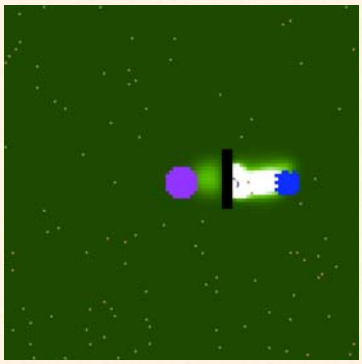

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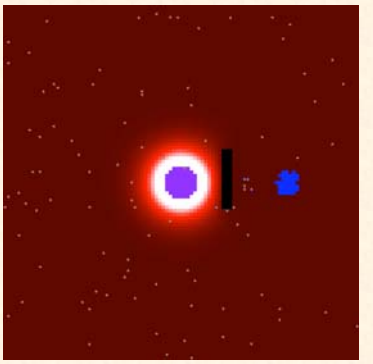

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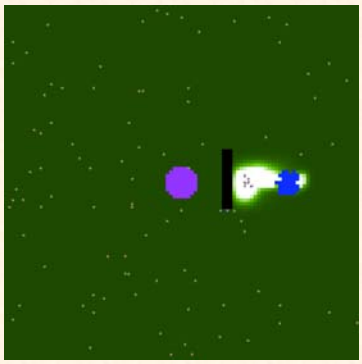

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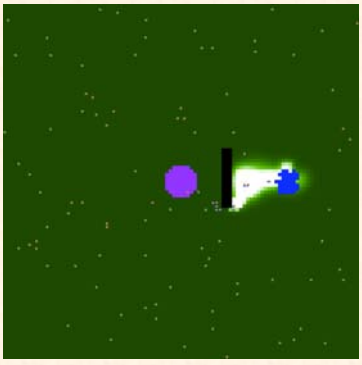

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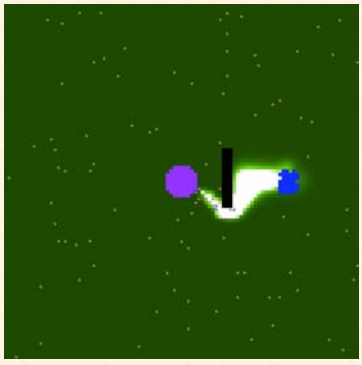

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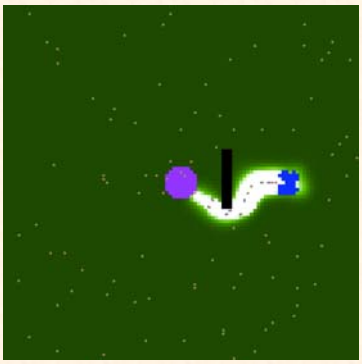
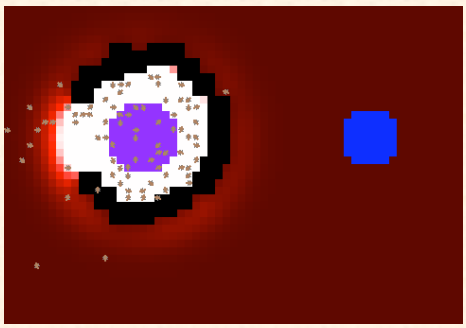
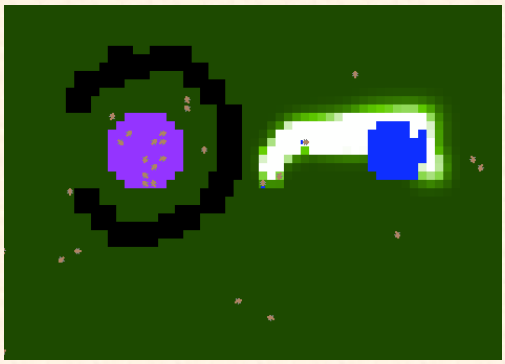
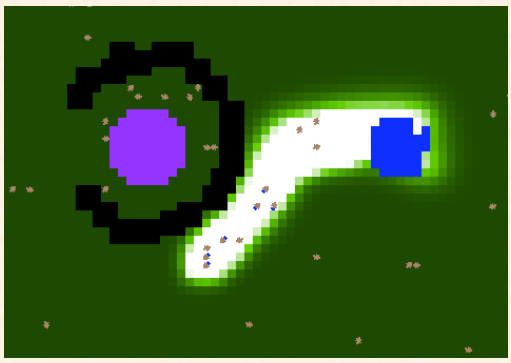
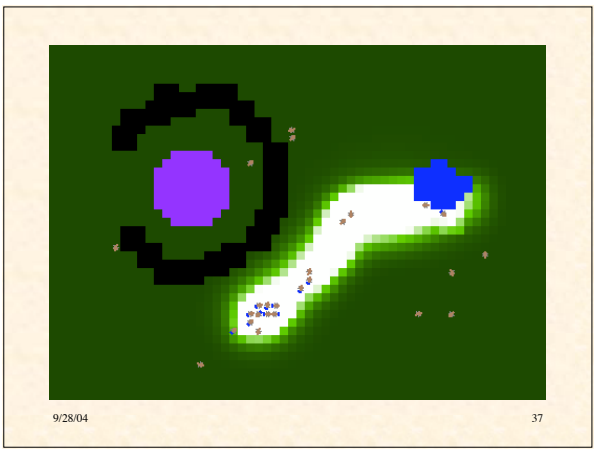


Avoiding a Barrier





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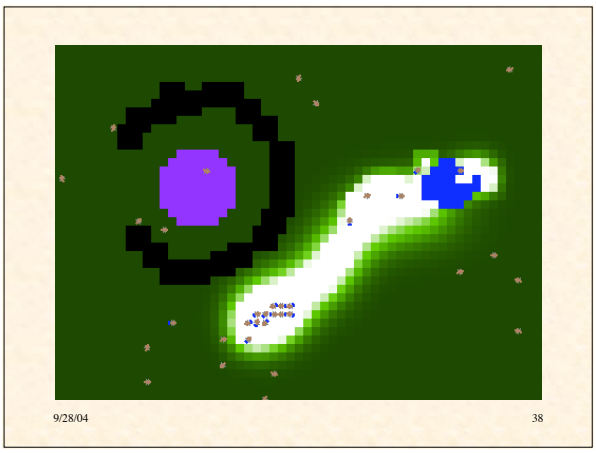
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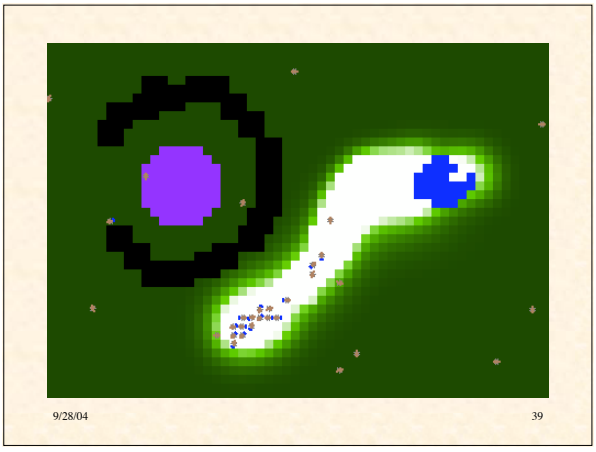
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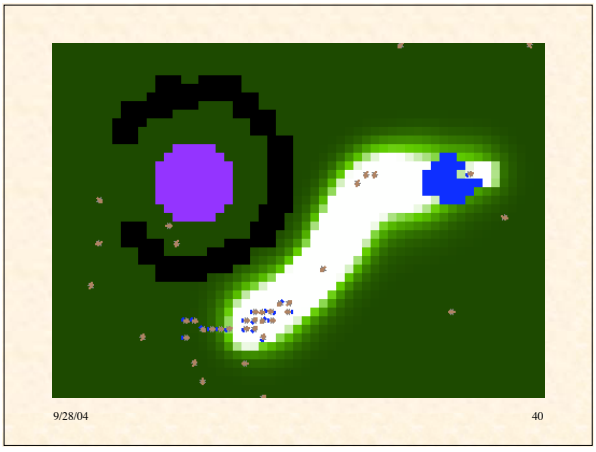
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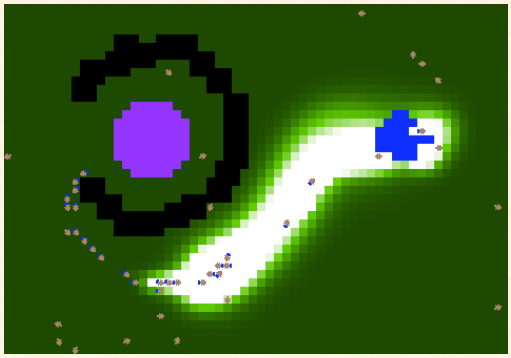

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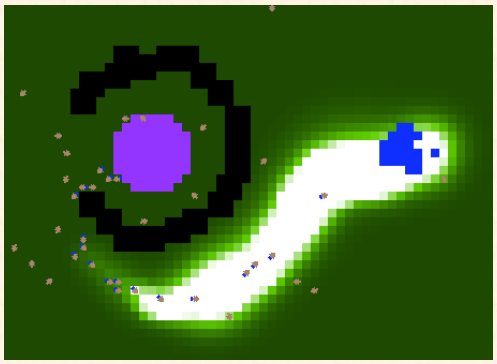

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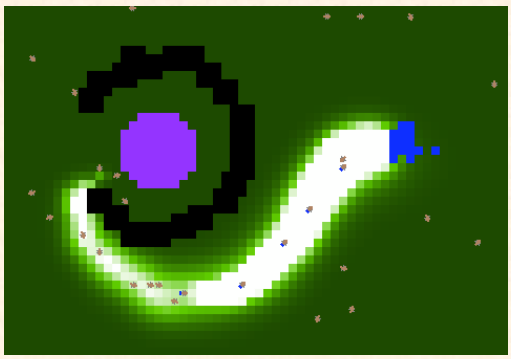

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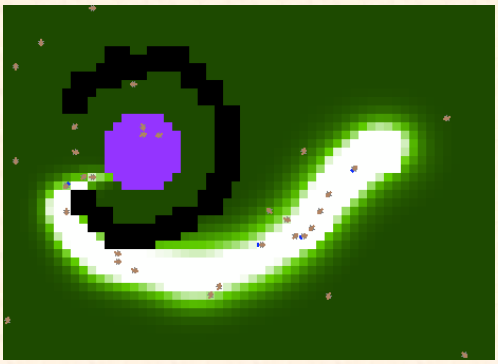

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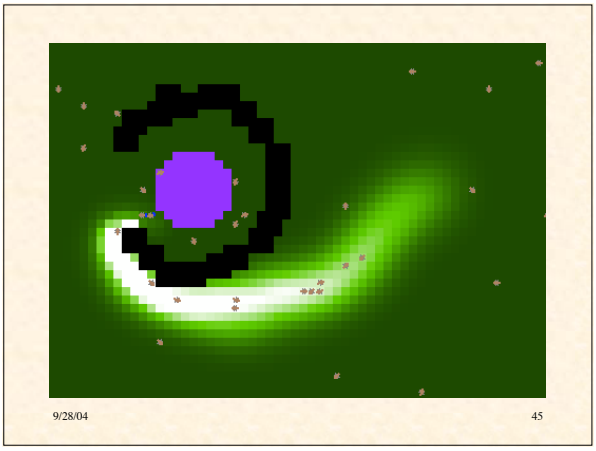
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