CS289 Lecture 2 Ant Foraging

S W A R R M T S

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Swarm Intelligence (1990s-)



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Swarm Intelligence





Foraging in Pheromone-laying Species

- Iridomyrmex humilis: Argentine Ant
- Lasius niger: Black Garden Ant (common in Europe)



Foraging for Food

- Amazing process
 - Find food is large unknown area (exploration)
 - Create single "highway" paths (many miles long)
 - Paths "improve" over time
 - Straighten and shorten, even repair
 - Solve "optimally" for complex scenarios
 - Multiple food sources, various quality, etc



- Question
 - How smart does an individual need to be if collective is large?
 - How does the collective become more than sum of its parts?
 - Answer: Not very! And Information-sharing
- How can we study the process?
 - Field studies + Lab games (or constrained scenarios)

Becker et al 1992 Model





• Bridge

- Like Prisoner's dilemma
- Tool to understand decision-making
- Reverse-engineering is hard!

• 3 Key Ideas

- Amplification (positive feedback)
- Population (repeated)
- Stigmergy (leave "notes" in environment)
- Implications
 - Find the shortest path
 - Select one, even if equal

Discussion Question 1

• Name some examples where we/people use a "stigmergy" like approach to communication.

Modeling

A. Agent Choice Model

$$Pr(L) = \frac{(k + L)^{n}}{(k+L)^{n} + (k+R)^{n}}$$

Or Pr (L) = $\frac{1}{1 + (R/L)^n}$

B. Agent Update Model

Constant update of path (e.g. I humilis) OR, Proportional to goodness (food carrying ants behave differently)



C. Ant Model Global View

Population of independent evaluators, Sharing information, with Positive feedback Possible models: ODEs/PDEs, or agent-based Example, dL/dt = influx of ants * Pr(take this path) + influx from other side TL time ago * Pr (take this path)

- loss due to evaporation









Army Ant Bridge Formation

Simon Garnier & Scott Powell Labs PNAS 2015





Discussion Question 2

- What are the important differences between
 - "stigmergy" (marking environment, implicit)
 - "direct" communication (agent-agent talking)
 - as a information sharing mechanism

Discussion Questions in Groups

- Redesign the ants so that they allocate "proportionally" to each food source by quality (or divide proportionally based on path length)
- Suppose you are conducting a search for a "source" in some arbitrary campus (unknown, rectangular obstacles) with humans. What strategy might you use?

Other Foraging Strategies: Army ants, Bees, Fish Other Related Problems: Coverage

Collective Clustering and Sorting

- Concept:
 - Ants cluster debris, larva, eggs into piles
- Behavior Model:

Pr (pickup) =
$$\frac{k^n}{k^n + f^n}$$

Pr (drop) = $\frac{f^n}{k^n + f^n}$
f = fraction nearby
= 0 (nothing), 1 (lots of stuff)

No pheromones!!



Citation: Deneubourg et al, "The dynamics of collective sorting: robot-like ants and ant-like robots", Conf on Simulation of Adaptive behaviors, 1990.