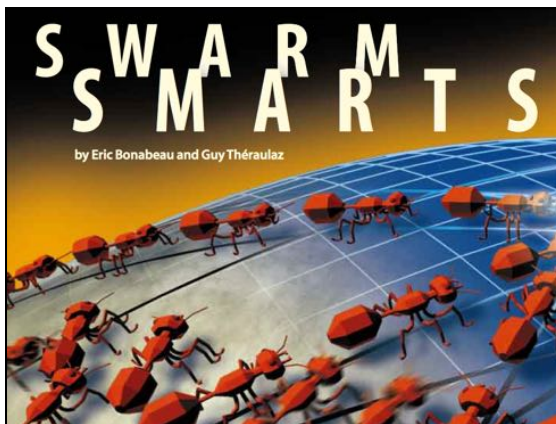


CS289 Lecture 2 Ant Foraging

Interlude: Class Expectations

- Discussion based class
 - Must read BOTH papers before class
 - Can eat in class
 - No laptops or iPhones, except for viewing paper or taking notes in class.
 - Interactive, And collaborative

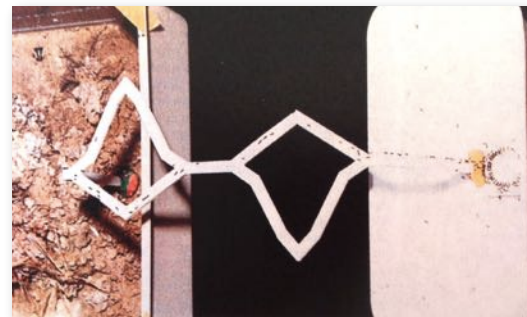
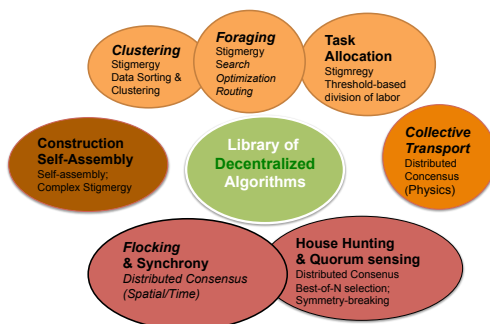


Swarm Intelligence (1990s-)



Eric Bonabeau (Physics), Guy Thérault (BIO), Maja Mataric (AI)
Jean-Louis Deneuborg (BIO), Marco Dorigo (CS), Rod Brooks (AI)

Swarm Intelligence



Foraging in Pheromone-laying Species

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

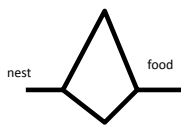


Foraging for Food

- 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 Basic 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

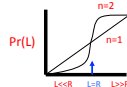
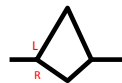
A. Agent Choice Model

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

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

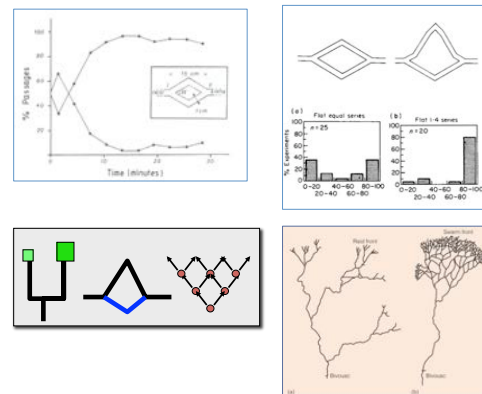
B. Agent Update Model

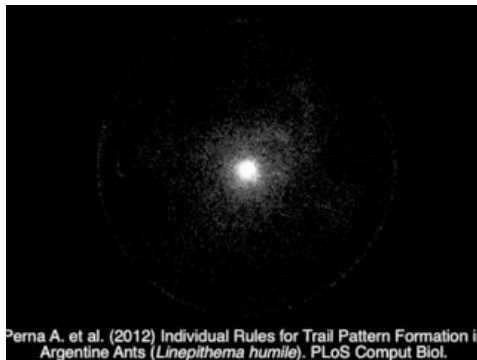
Constant update of path (e.g. *I. humilis*)
OR, Proportional to goodness
(food carrying ants behave differently)



C. Ant Model Global View

Population of independent evaluators, Sharing information, with Positive feedback
Possible models: ODEs/PDEs, or agent-based
Example, $dL/dt = \text{influx from other side TL time ago} * \Pr(\text{take this path})$
– loss due to evaporation

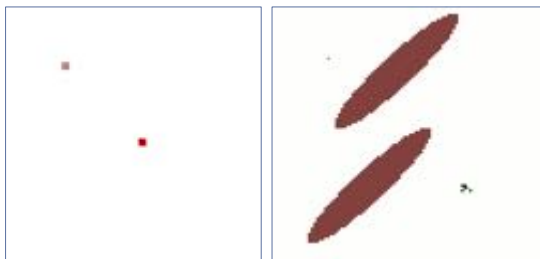




Perna A. et al. (2012) Individual Rules for Trail Pattern Formation in Argentine Ants (*Linepithema humile*). PLoS Comput Biol.

Argentine Ant Trails, by Couzin Lab, PLOS Compbio 2012

Army Ant Bridge Formation
Simon Garnier &
Scott Powell Labs
PNAS 2015



Modeling Pheromone-based Trail Formation in 2D

Panait and Luke, AAMAS 2004

Ant Foraging Simulations (George Mason Univ) <http://www.cs.gmu.edu/~lpanait/research/ants/>

Discussion Question 2

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