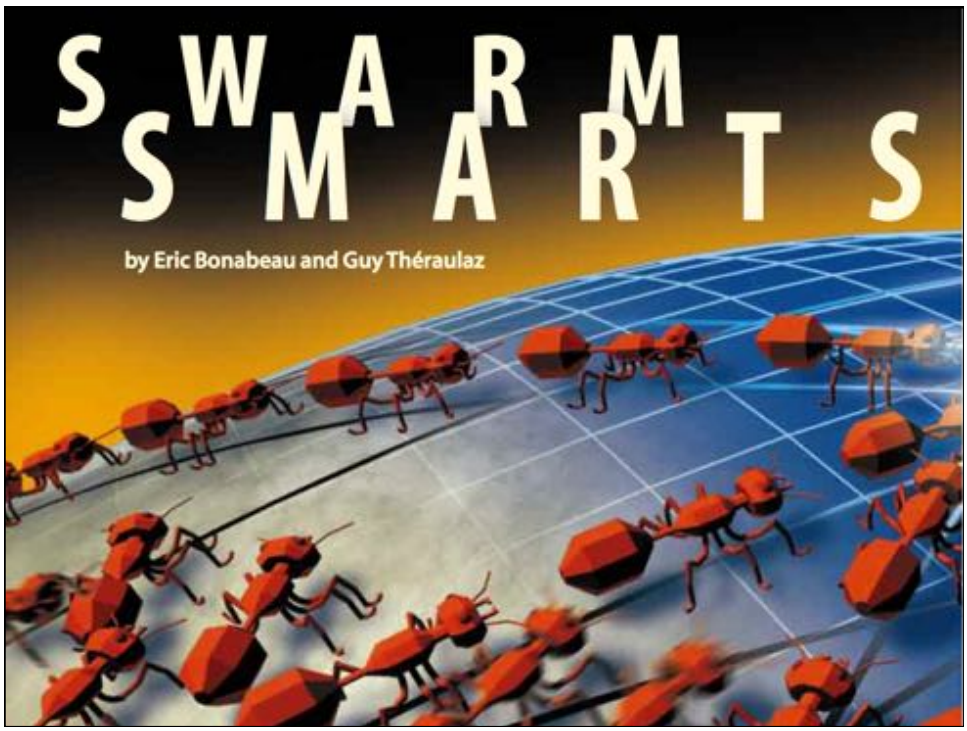
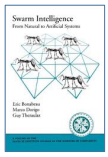
CS289 Lecture 2
Ant Foraging

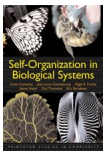
Interlude: Class Expectations

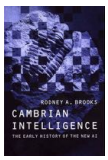
- Discussion based class
  - Must read BOTH papers before class
  - Can eat in class
  - No laptops or iphones, except for viewing paper or taking notes in class.
  - Interactive, And collaborative



Swarm Intelligence (1990s-)

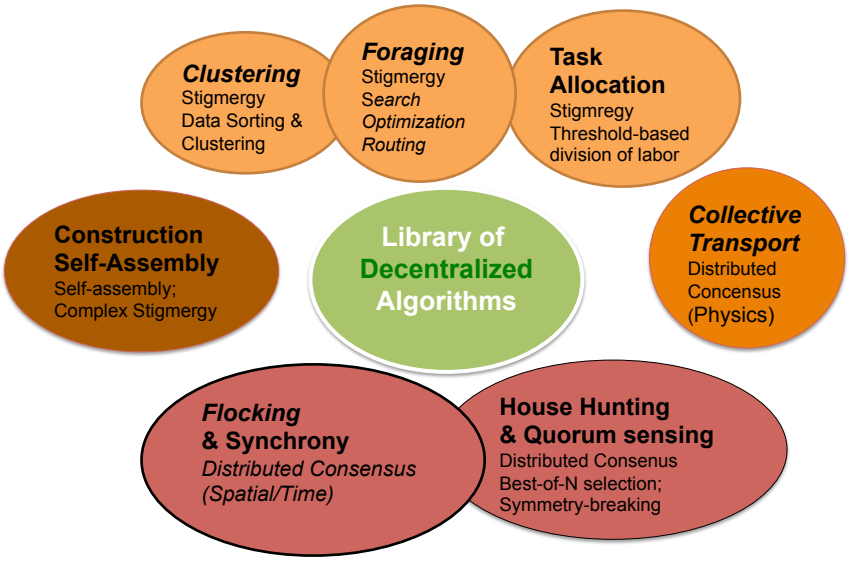


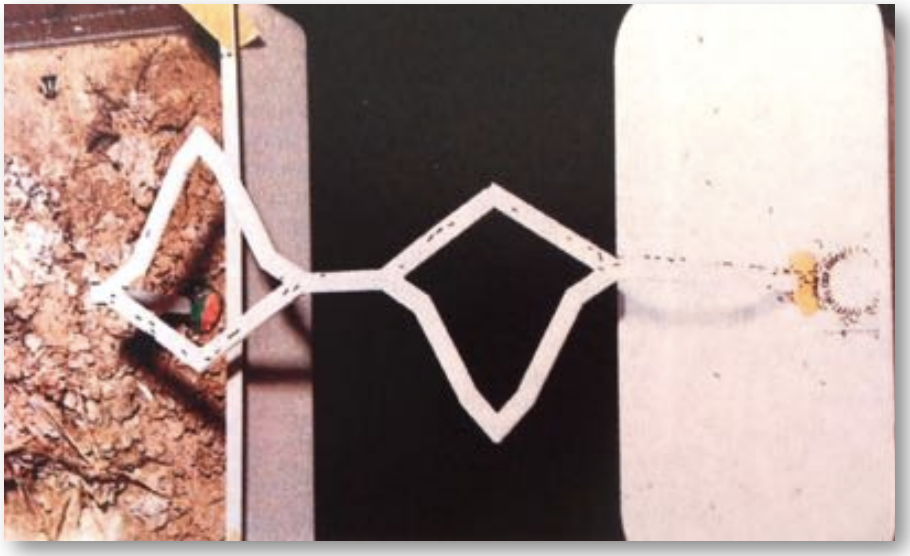




Eric Bonabeau (Physics), Guy Theralauz (BIO), Maja Mataric (AI)
Jean-Louis Deneuborg (BIO), Marco Dorigo (CS), Rod Brooks (AI)

Swarm Intelligence





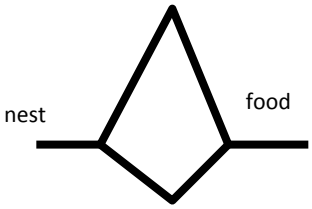
Foraging in Pheromone-laying Species

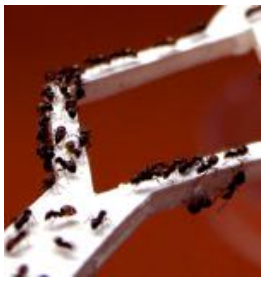
- Iridomyrmex humilis: Argentine Ant
- Lasius niger: Black Garden Ant (common in Europe)

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

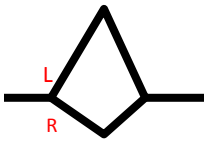
- Name some examples where we/people use a "stigmergy" like approach to communication.

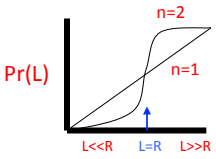
Modeling

A. Agent Choice Model

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

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



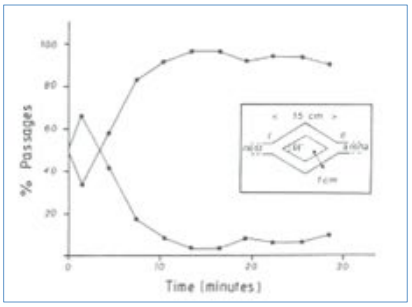


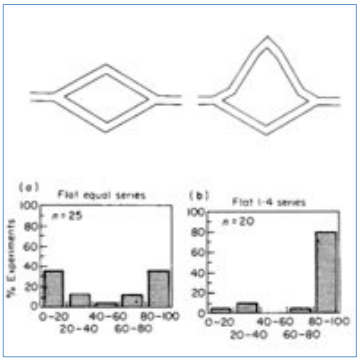
B. Agent Update Model

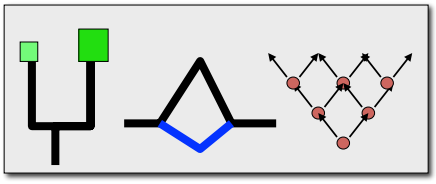
Constant update of path (e.g. I humilis)
OR, Proportional to goodness
(food carrying ants behave differently)

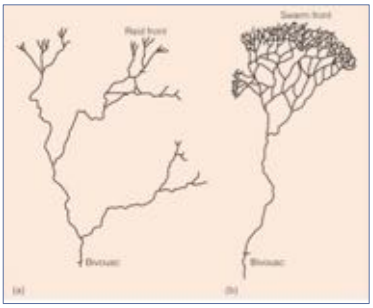
C. Ant Model Global View

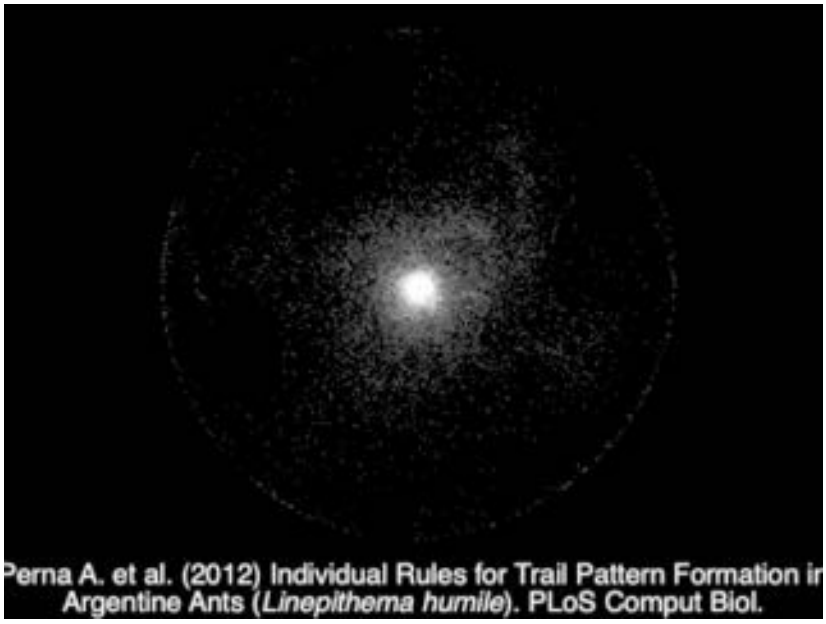
Population of independent evaluators, Sharing information, with Positive feedback
Possible models: ODEs/PDEs, or agent-based
Example, dL/dt = influx of ants * Pr(take this path)
+ influx from other side TL time ago * Pr (take this path)
- loss due to evaporation





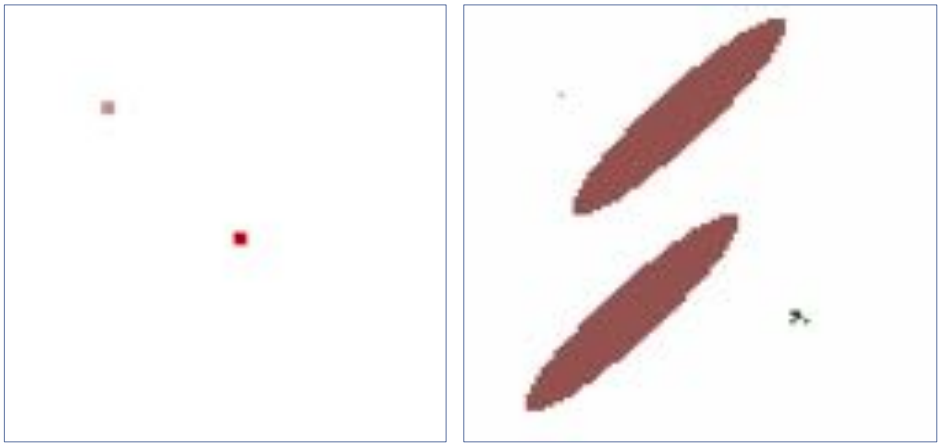






Argentine Ant Trails, by Couzin Lab, PLOS Compbio 2012

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