Presenter Days (next week, 3 days)

- 2 Papers per lecture, no reviews due.
- Presenter Duties
  - 30 minutes talk with slides (laptop/download)
  - Both members should present together
  - Stick with the content of the paper
    - Possible Order: Motivation, Problem they tried to solve, Results, and then Methods.
    - Read up on background papers/authors for context.
    - Relate back to topics covered in class
    - If necessary, cover unfamiliar bag(e.g. ML), do some
    - Q&A session at the end of the class (15 min)

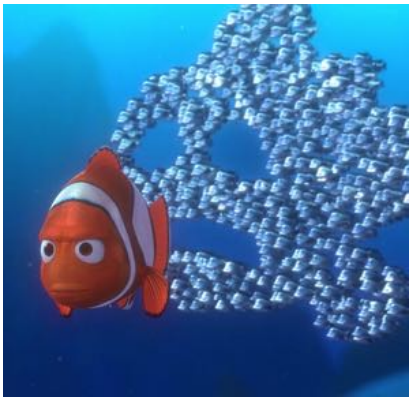
1

Self-Reconfigurable "Cellular" Robots

CS289

2

Science Fiction



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Science Fiction

4

Science Fiction

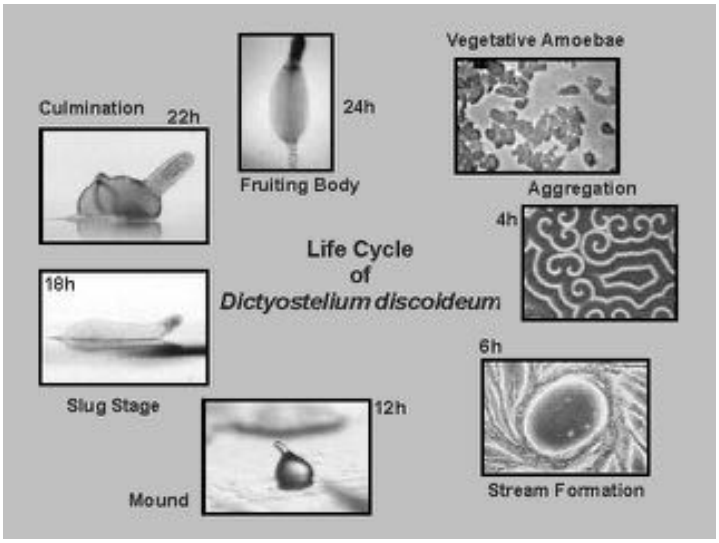
5

Reality

Stranger than Fiction?

6

Cellular Slime Mold



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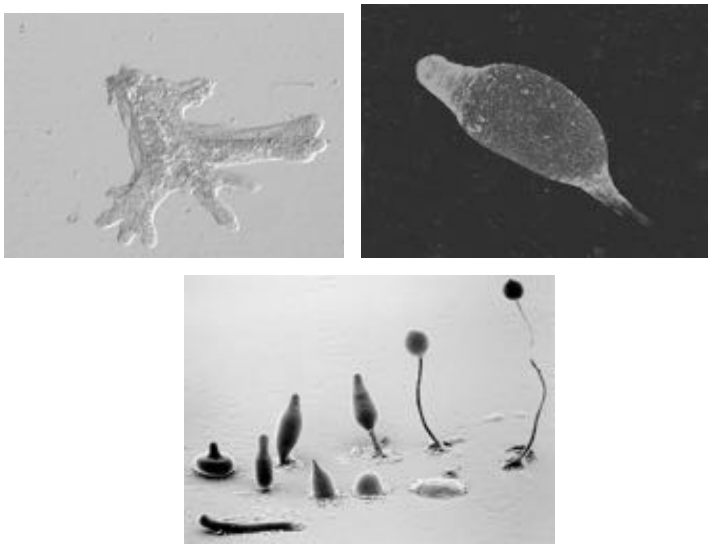
Cellular Slime Mold



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Army Ants, Bridges & Bivouacs!

Daniel Kronauer, Rockefeller Univ;, Simon Garnier, NJIT; Scott Powell, G. Washington Univ

9

Reality

to Robots….

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Challenges

What is a necessary & sufficient individual "module" to create interesting "collective" robots.

- **Mechanical Design Challenge**
  - Movement, attachment, power
- **Programming Challenge**
  - Global-to-local, scalable, robust

Both are closely linked……

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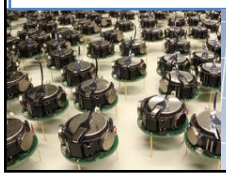
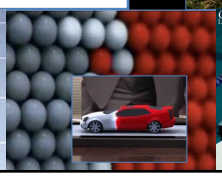
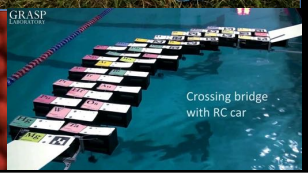
Mechanical Design Challenge

- Historical
  - CEBOT (Fakuda), Fracta (Murata)
- Chain-style Robots
  - Polybot, Superbot, Mtran (Yim, Shen, Murata/Kurokawa)
- Lattice-style Robots
  - E.g. ATRON (Ostergaard, Stoy)
- Stochastic Robots
  - Programmable Parts, Molecube (Klavins, Lipson)
- Programmable Materials
  - Pebbles (Rus) Claytronics (Goldstein)
- Applications:
  From Space Exploration to Novel Displays!







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Challenges

What is a necessary & sufficient individual "module" to create interesting "collective" robots.

- **Mechanical Design Challenge**
  - Movement, attachment, power
- **Programming Challenge**
  - Global-to-local, scalable, robust

Both are closely linked……

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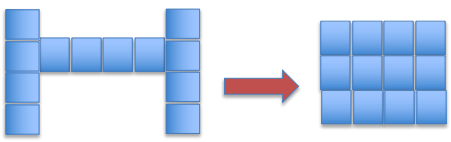
Challenges

Programming Challenge => Many Approaches

1. **Centralized Planning**
   1. Find minimum number of steps to transform shape A to B, given movement and other constraints (e.g. connectedness)
   2. But, mostly NP hard and fragile.



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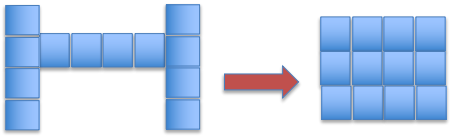
Challenges

Programming Challenge => Many Approaches

1. **Centralized Planning**
    1. Find minimum number of steps to transform shape A to B, given movement and other constraints (e.g. connectedness)
    2. But, mostly NP hard and fragile.

2. **Decentralized:**
    1. Cellular Automata (ala Lindemayer grammars, Rus et al)
    1. DevelBio-inspired (e.g. morphogen gradients, Shen et al)
    2. Chemistry-Inspired ("tiles" that stick, Klavins et al)



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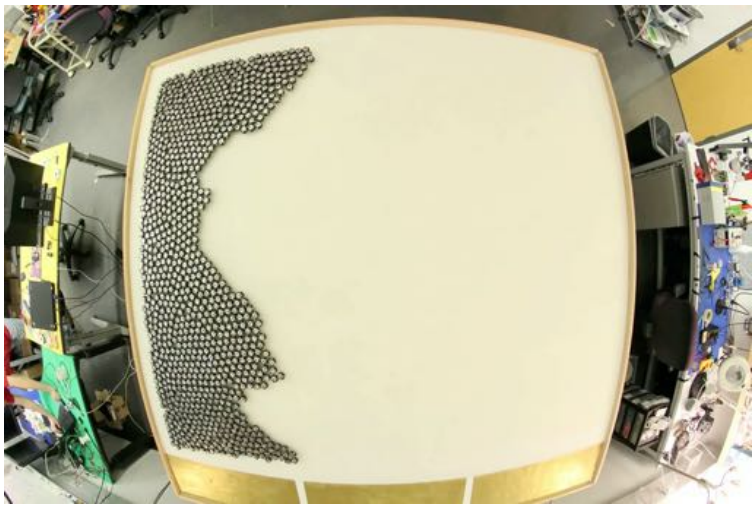
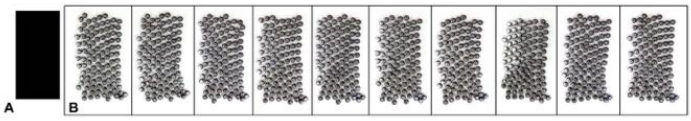
Today's papers: KIlobots



Michael Rubenstein, Alex Cornejo, Nagpal, Science 2014



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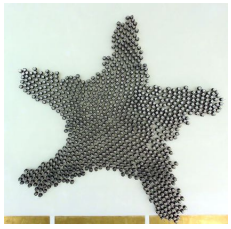
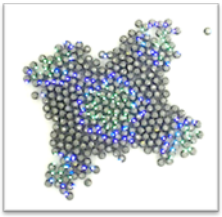
Discussions

In today's papers you saw two "approaches"
(1) Directed Growth & (2) Turing approach





What other approaches can you think of?
(relating back to the developmental biology chapter)

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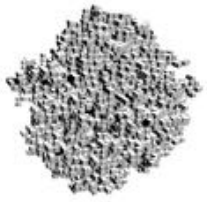
Other Approaches

Directed Growth in 3D, with morphogens



Kasper Stoy, University of Southern Denmark, 2004

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Other Approaches

Shape Formation through Apoptosis

Keith Kotay and Daniela Rus, MIT (Pebbles project)
Gauci. Rubenstein, Nagpal, 2016

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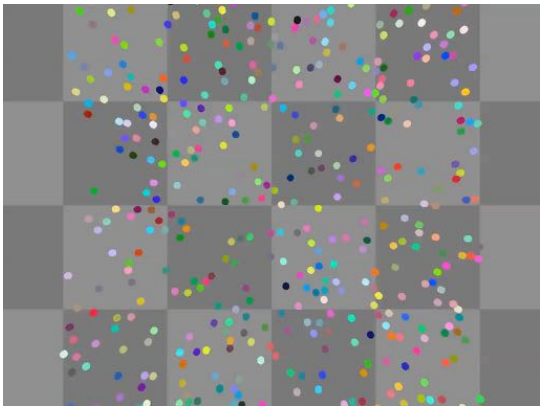
Other Approaches

- Self-Regeneration after damage



Mike Rubenstein and Wei-Min Shen, University of Southern California, 2010

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