

Self-Reconfigurable "Cellular" Robots

CS289, 2017

Science Fiction



Science Fiction

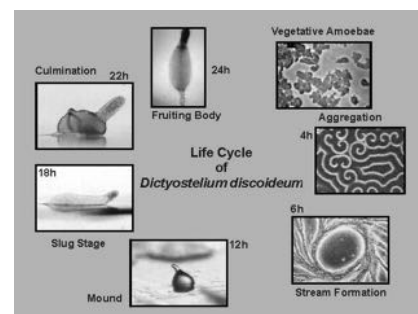


Science Fiction

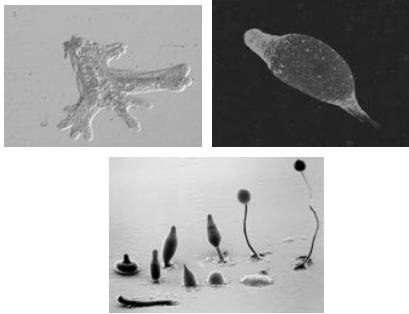


Reality Stranger than Fiction?

Cellular Slime Mold



Cellular Slime Mold



Army Ants, Bridges & Bivouacs!



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

Reality
to Robots....

Challenges

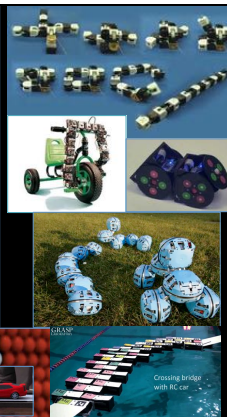
What is a necessary & sufficient individual “module” to create interesting “collective” robots.

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

Both are closely linked.....

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 (Goldtsein)
- Applications:
 - From Space Exploration to Novel Displays!



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.....

Challenges

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

– Mechanical Design Challenge

- Mechanical Design Challenge
- Programming Challenge => Many Approaches

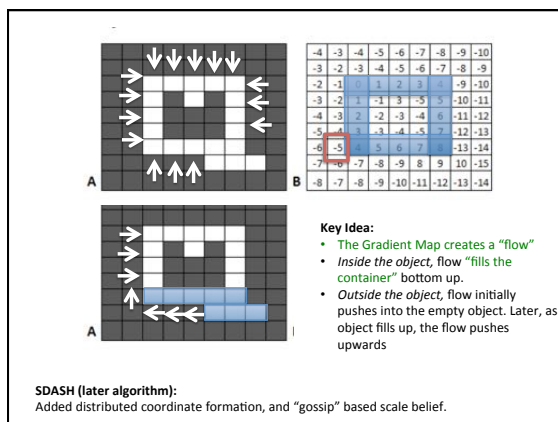
– Programming Challenge

- Global Planning
 1. Centralized Planning :
 1. Find minimum number of steps to transform shape A to B.
 2. But, mostly NP hard and fragile
 2. Decentralized:
 1. Cellular Automata (Rus et al)
 1. Bio-inspired (e.g. morphogen gradients, Shen et al)
 2. Chemistry Inspired (“tiles” that stick to each other, Klavins et al)
- Local Planning

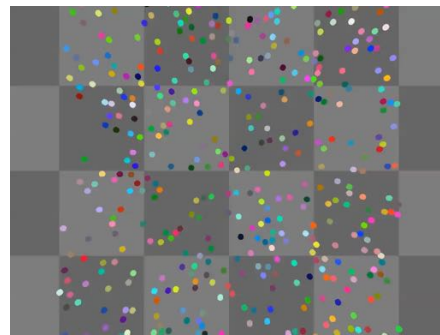
Both are

Discussions

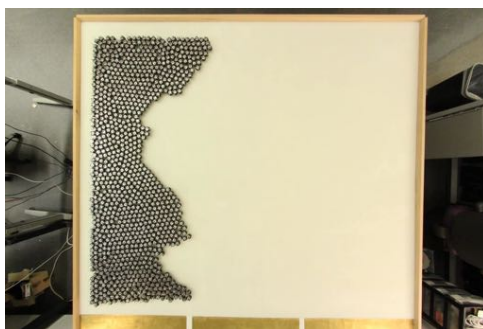
The goal of the DASH algorithm is
 “programmable self-assembly with self-repair”
 – What are the key elements of the DASH algorithm?



Rubenstein and Shen



Rubenstein’s Kilobots



Discussions

- What are the differences between:
 - DASH vs Yamin’s (Theory->Simulation)
 - DASH vs Kilobots (Abstract->Physical)
 - DASH vs Biology (“French Flag” approach)