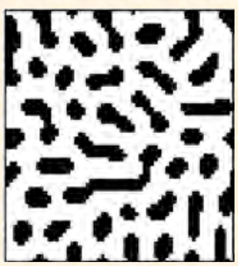
Lecture 9

Abstract Activation/Inhibition Spaces

- Consider two axes of cultural preference
  - E.g. hair length & interpersonal distance
  - Fictitious example!
- Suppose there are no objective reasons for preferences
- Suppose people approve/encourage those with similar preferences
- Suppose people disapprove/discourage those with different preferences
- What is the result?

Emergent Regions of Acceptable Variation



A Key Element of Self-Organization

- Activation vs. Inhibition
- Cooperation vs. Competition
- Amplification vs. Stabilization
- Growth vs. Limit
- Positive Feedback vs. Negative Feedback
  - Positive feedback creates
  - Negative feedback shapes

Reaction-Diffusion Computing

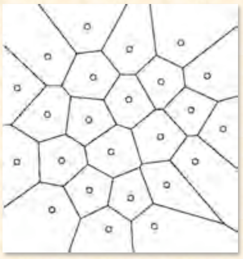
- Has been used for image processing
  - diffusion ⇒ noise filtering
  - reaction ⇒ contrast enhancement
- Depending on parameters, RD computing can:
  - restore broken contours
  - detect edges
  - improve contrast

Image Processing in BZ Medium

- (A) boundary detection, (B) contour enhancement, (C) shape enhancement, (D) feature enhancement

 Image < Adamatzky, *Comp. in Nonlinar Media & Autom. Coll.*

Voronoi Diagrams



- Given a set of generating points:
- Construct polygon around each gen. point of set, so all points in poly. are closer to its generating point than to any other generating points.

9/20/07 Image < Adamatzky & al., *Reaction-Diffusion Computers* 7

Some Uses of Voronoi Diagrams

- Collision-free path planning
- Determination of service areas for power substations
- Nearest-neighbor pattern classification
- Determination of larges empty figure

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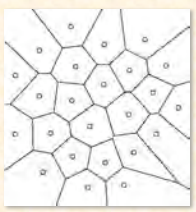
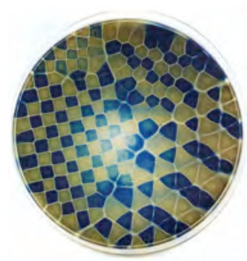
Computation of Voronoi Diagram by Reaction-Diffusion Processor



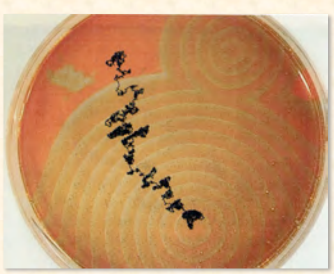
9/20/07 Image < Adamatzky & al., *Reaction-Diffusion Computers* 9

Mixed Cell Voronoi Diagram



9/20/07 Image < Adamatzky & al., *Reaction-Diffusion Computers* 10

Path Planning via BZ medium: No Obstacles



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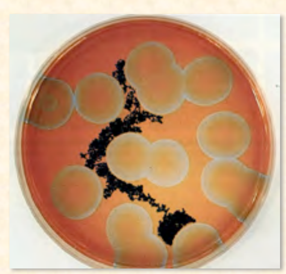
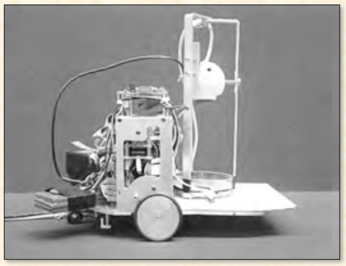
Path Planning via BZ medium: Circular Obstacles



9/20/07 Image < Adamatzky & al., *Reaction-Diffusion Computers* 12

Mobile Robot with Onboard Chemical Reactor

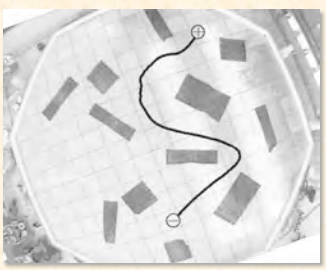


9/20/07 Image < Adamatzky & al., *Reaction-Diffusion Computers* 13

Actual Path: Pd Processor

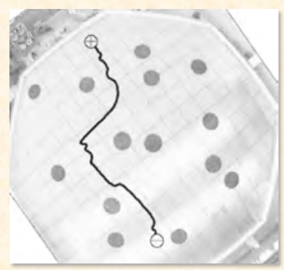
9/20/07 Image < Adamatzky & al., *Reaction-Diffusion Computers* 14

Actual Path: Pd Processor



9/20/07 Image < Adamatzky & al., *Reaction-Diffusion Computers* 15

Actual Path: BZ Processor



9/20/07 Image < Adamatzky & al., *Reaction-Diffusion Computers* 16

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III
Autonomous Agents
&
Self-Organization

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Autonomous Agent

- "a unit that interacts with its environment (which probably consists of other agents)
- but acts independently from all other agents in that it does not take commands from some seen or unseen leader,
- nor does an agent have some idea of a global plan that it should be following."

—Flake (p. 261)

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Nest Building by Termites (Natural and Artificial)

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Resnick's Termites ("Turmites")

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Basic procedure

- Wander randomly
- If you are not carrying anything and you bump into a wood chip, pick it up.
- If you are carrying a wood chip and you bump into another wood chip, put down the woodchip you are carrying

— Resnick, *Turtles, Termites, and Traffic Jams*

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Microbehavior of Turmites

1. *Search for wood chip:*
   a) If at chip, pick it up
   b) otherwise wiggle, and go back to (a)
2. *Find a wood pile:*
   a) If at chip, it's found
   b) otherwise wiggle, and go back to (a)
3. *Find an empty spot and put chip down:*
   a) If at empty spot, put chip down & jump away
   b) otherwise, turn, take a step, and go to (a)

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Demonstration

Run Termites.nlogo

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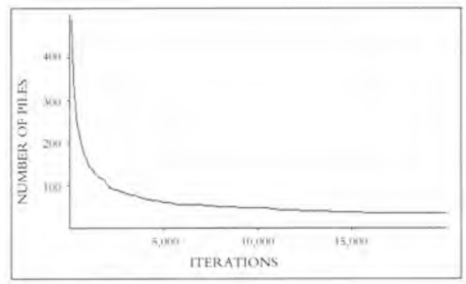
Decrease in Number of Piles



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Why does the number of piles decrease?

- A pile can grow or shrink
- But once the last chip is taken from a pile, it can never restart
- Is there any way the number of piles can increase?
- Yes, and existing pile can be broken into two

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More Termites

Termites	2000 steps		10 000 steps		
	num. piles	avg. size	num. piles	avg. size	chips in piles
1000	102	15	47	30	
4000	10		3	80	240

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Termite-Mediated Condensation

- Number of chips is conserved
- Chips do not move on own; movement is mediated by termites
- Chips preferentially condense into piles
- Increasing termites, increases number of chips in fluid (randomly moving) state
- Like temperature

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An Experiment to Make the Number Decrease More Quickly

- Problem: piles may grow or shrink
- Idea: protect "investment" in large piles
- Termites will not take chips from piles greater than a certain size
- Result: number decreases more quickly
- Most chips are in piles
- But *never* got less than 82 piles

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Conclusion

- In the long run, the “dumber” strategy is better
- Although it’s slower, it achieves a better result
- By not protecting large piles, there is a small probability of any pile evaporating
- So the smaller “large piles” can evaporate and contribute to the larger “large piles”
- Even though this strategy makes occasional backward steps, it outperforms the attempt to protect accomplishments