Emergence of Macro Spatial Structures in Dissipative Cellular Automata

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Motivations

- ▶ Explore the behavior of asynchronous and open CA.
- ▶ Simple model for multiagent systems.

Outline

- Dissipative Cellular Automata
- Experimental setting
- Emerging behavior
- Future work

Dissipative Cellular Automata

Two main characteristics:

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- Asynchronous

Asynchronous dynamics

Asynchronous time-driven dynamics:

at each time step, a cell has a probability λ_a to wake up and update its state.

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- Open

Asynchronous dynamics

Asynchronous time-driven dynamics:

at each time step, a cell has a probability λ_a to wake up and update its state.

- The update is atomic and mutually exclusive among neighbors, without preventing non-neighbor cells to update their state concurrently.

Openness

The dynamic behavior of the CA can be influenced by the external environment:

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→ some cells can be forced from the external to change their state.

Every cell has a probability λ_e to be perturbed.

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→ some cells can be forced from the external to change their state.

Experiment setting

- CA with 2 states (dead/alive, 0/1)
- 2-dimensional grid (closed on a torus)
- Perturbation: a cell is forced to be “alive”
- λ_a and λ_e are the same for every cell

Experiment setting

Examples of rules/neighborhoods:

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- Neighborhood: 12 cells
- Rule: a dead cell gets alive if it has 6 neighbors alive; a living cells lives if it has 3,4,5, or 6 neighbors alive

Experiment setting

Examples of rules/neighborhoods:

- Neighborhood: 8 cells
- Rule: a dead cell gets alive if it has 2 neighbors alive; a living cells lives if it has 1 or 2 neighbors alive

Experiments

Main result:

► **emergence of regular patterns**

Experiments

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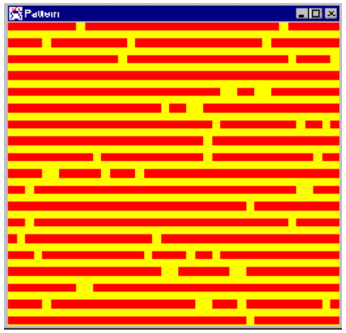
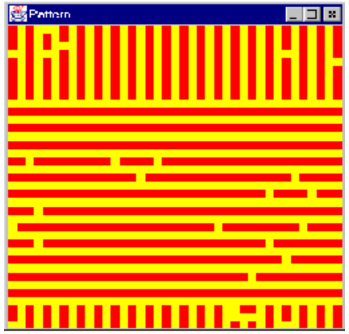
- **emergence of regular patterns**

The behavior is strongly different from *close* CA.

Experiments

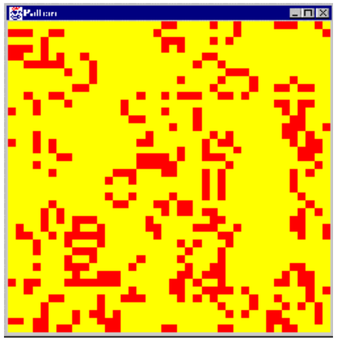
Two final attractors:

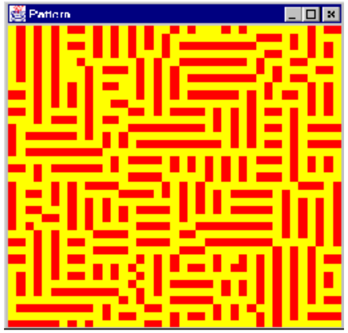




Experiments

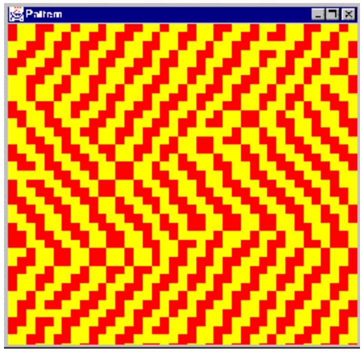
The synchronous and asynchronous versions. . .

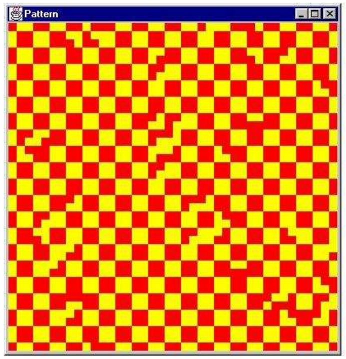




Experiments

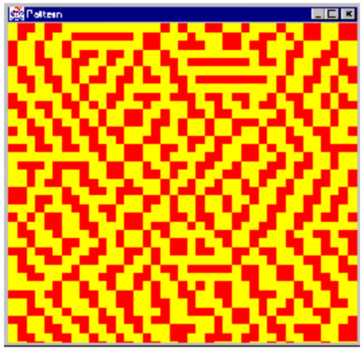
Example with 12 neighbors





Experiments

The asynchronous and **close** version



λ_e/λ_a ratio

Observation

Patterns appear only for a specific range of the ratio λ_e/λ_a.

$\lambda_e << \lambda_a \rightarrow$ no effect

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$\lambda_e \approx \lambda_a \rightarrow$ turbulence

Emergent patterns vs. λ_e/λ_a

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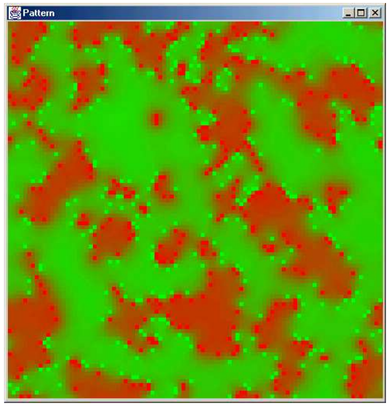
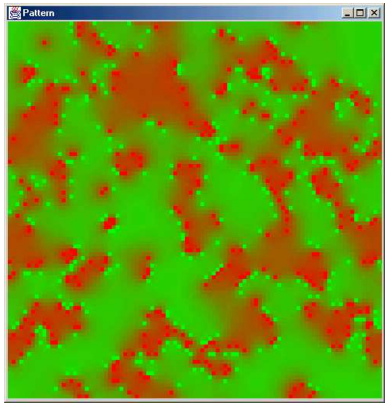
256-states DCA



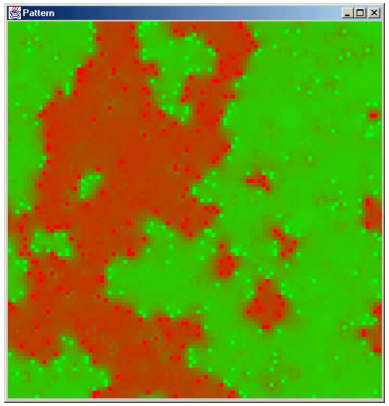
$\lambda_e/\lambda_a = 0.001$

256-states DCA



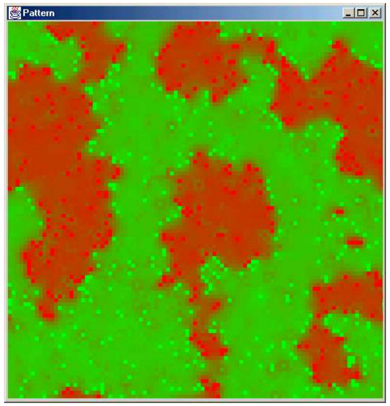
$\lambda_e/\lambda_a = 0.01$

256-states DCA



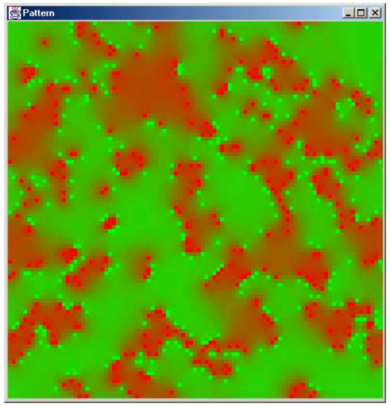
$\lambda_e/\lambda_a = 0.02$

256-states DCA



$\lambda_e/\lambda_a = 0.05$

256-states DCA



$\lambda_e/\lambda_a = 0.01$

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- Different measures for evaluating the emergence of patterns

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http://polaris.ing.unimo.it/DCA/