EvoCell

free software for
designing and evolving
cellular automata

http://kybernet.org/wiki/EvoCell
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Agenda

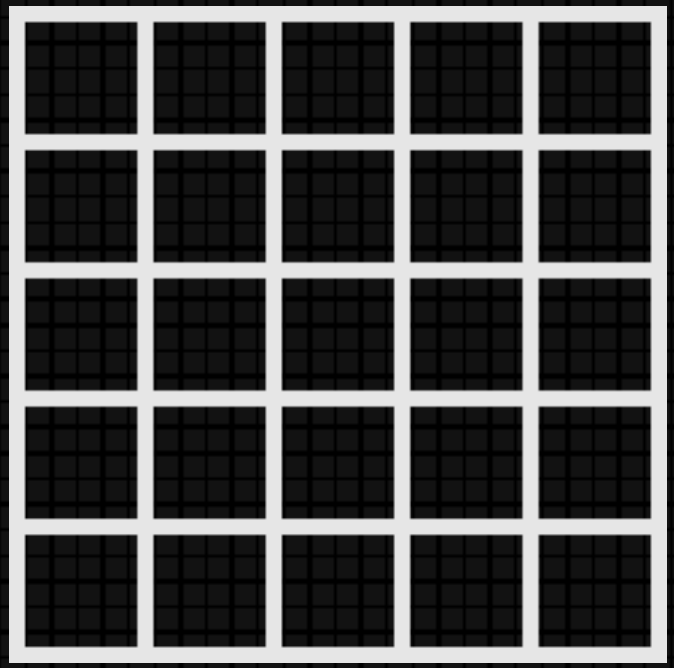
- Introduction to Cellular Automata
- Demo of EvoCell
- Artificial Life in Cellular Automata
- Resume

Cellular automata

- Introduced by von Neumann and Ulam
  - http://cba.mit.edu/events/03.11.ASE/docs/VonNeumann.pdf
- Mathematical model
  - Dynamical system
  - Discrete in time
  - Discrete in space
  - Only local interaction
- Global phenomena out of local interaction

Elements of a cellular automaton

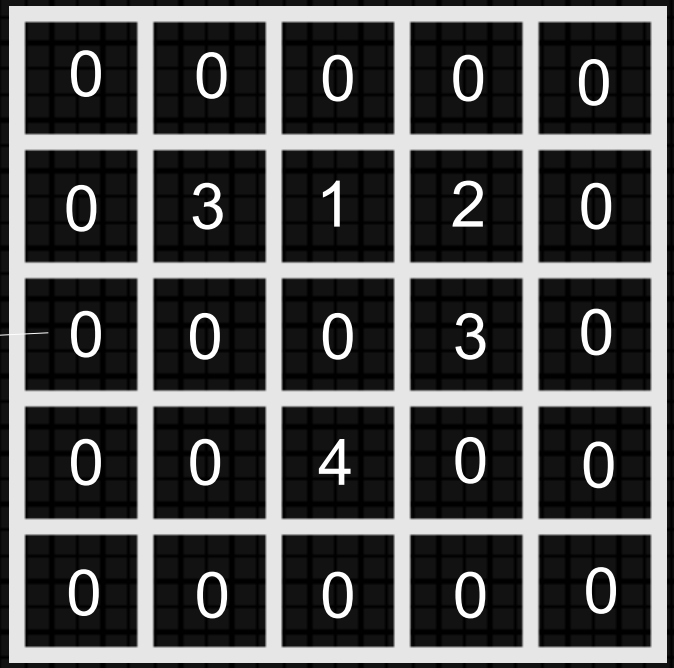
Some regular lattice of cells



Elements of a cellular automaton

Some regular lattice of cells

At each time step each cell is in one of **s** states

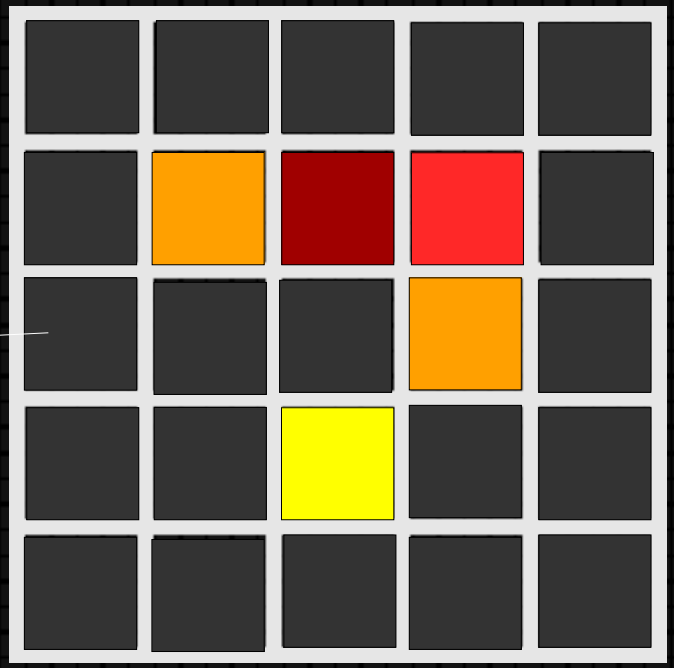


Elements of a cellular automaton

Some regular lattice of cells

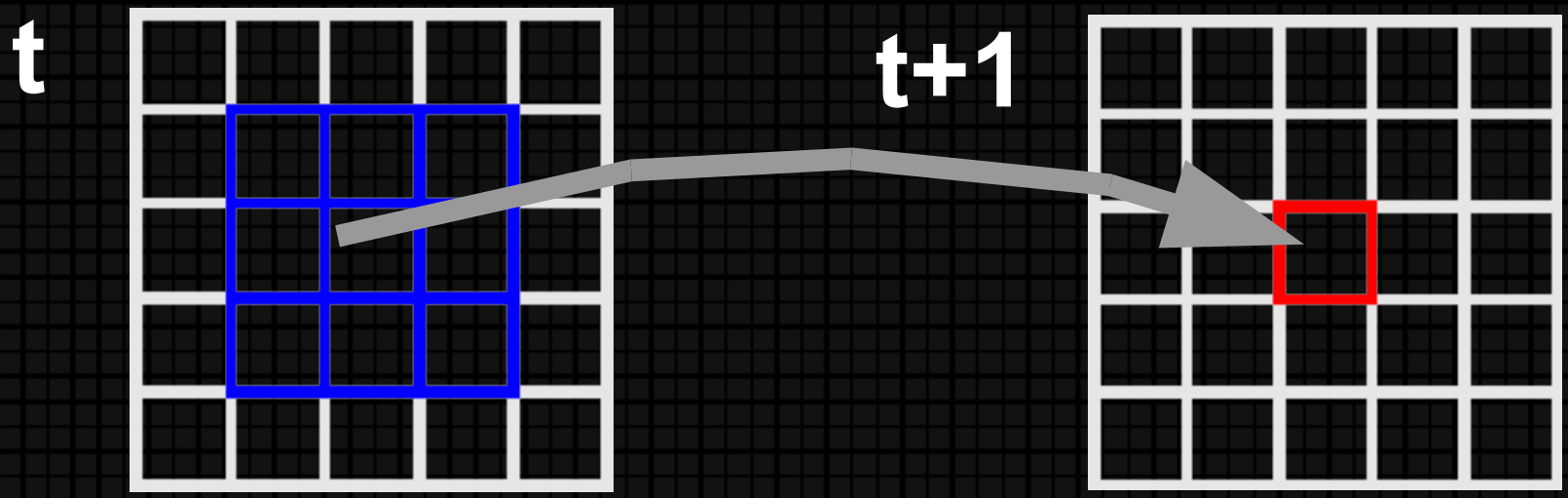
At each time step each cell is in one of **s** states

States coded by color for visualisation



Neighbourhood

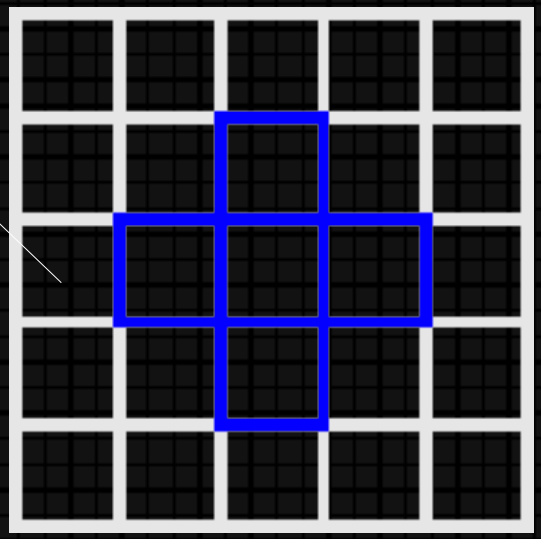
- The state of each cell at time step **t+1** is a **function** of some of its surrounding cells (the neighbours) at time step **t**

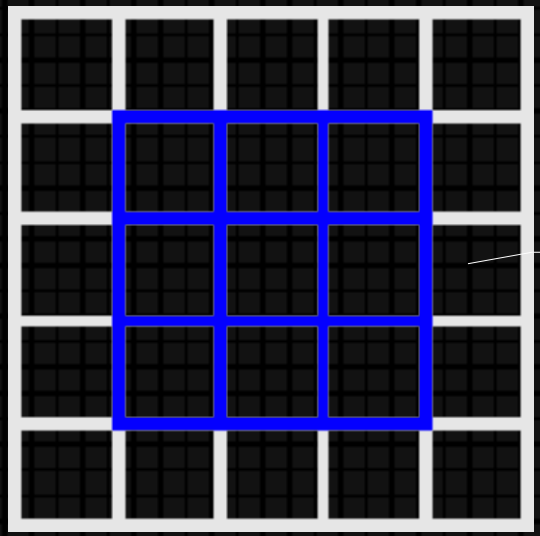


- The neighbourhood is the same for each cell
- The center cell is usually included in the neighbourhood

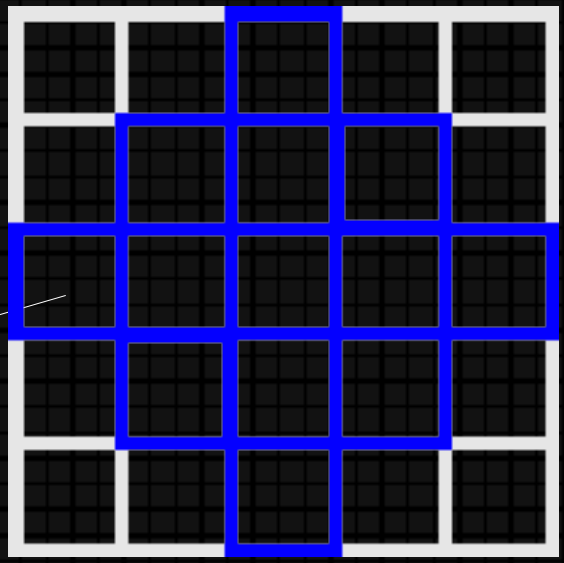
Typical neighbourhoods

Von Neumann





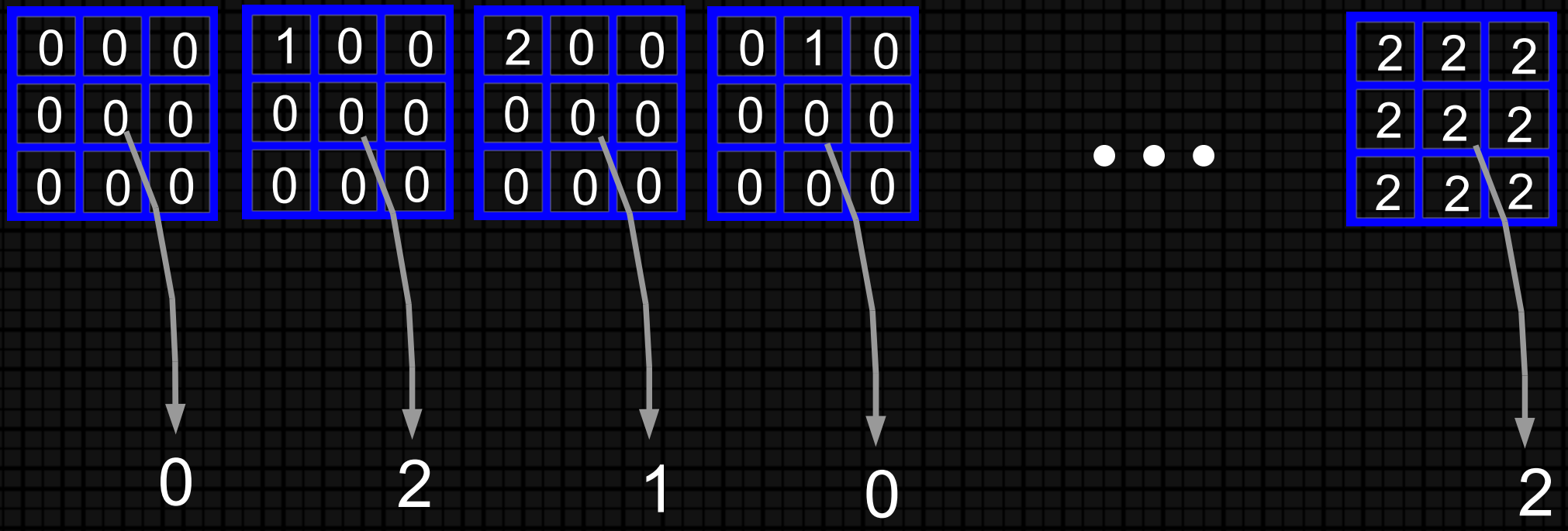
Moore



“Big“

Transition Function

- For each possible combination of states in the neighbourhood there is a target state the center cell develops into.
- Implemented as a look-up-table
- Example: Moore Neighbourhood, 3 states



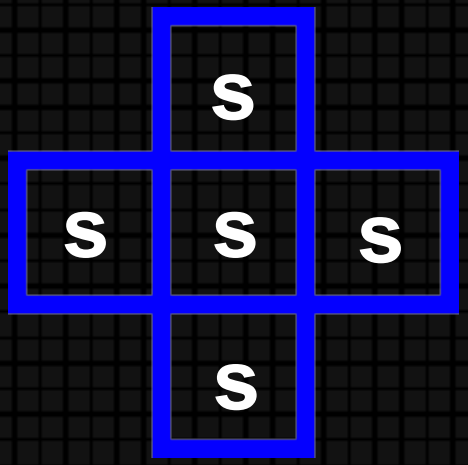
Elements of a cellular automaton (Summary)

- a lattice geometry
  - Defines how the cells are aligned to each other
- a number of states the cells can be in (**s**)
- a neighbourhood (**n** neighbours)
- a transition function
  - The neighbourhood and the transition function define the local interactions

How many different CA do exist?

First: How many different neighbourhoods do exist?

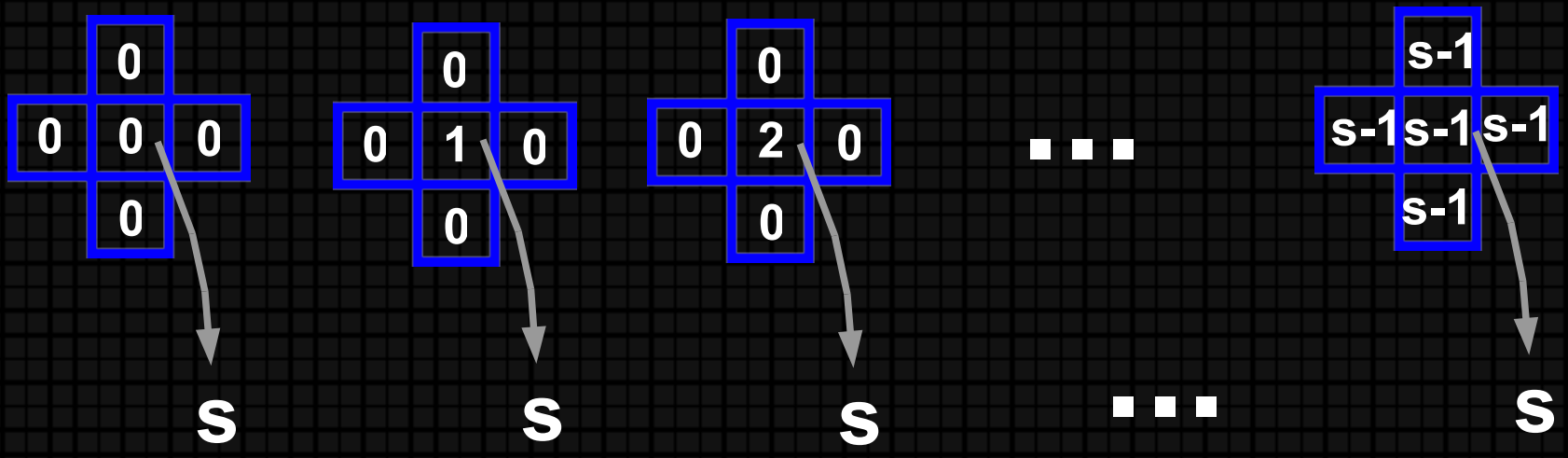
Each of the **n** cells in the neighbourhood can be in one of **s** states



So there are **s*s*s*s*s = s^n** different neighbourhoods

How many different CA do exist?

For each of these **s^n** neighbourhoods we have to assign one target state.



So there are **s^(s^n)** different possible CA

This is a huge number!

How do we find the interesting points in this huge space of possible CA?

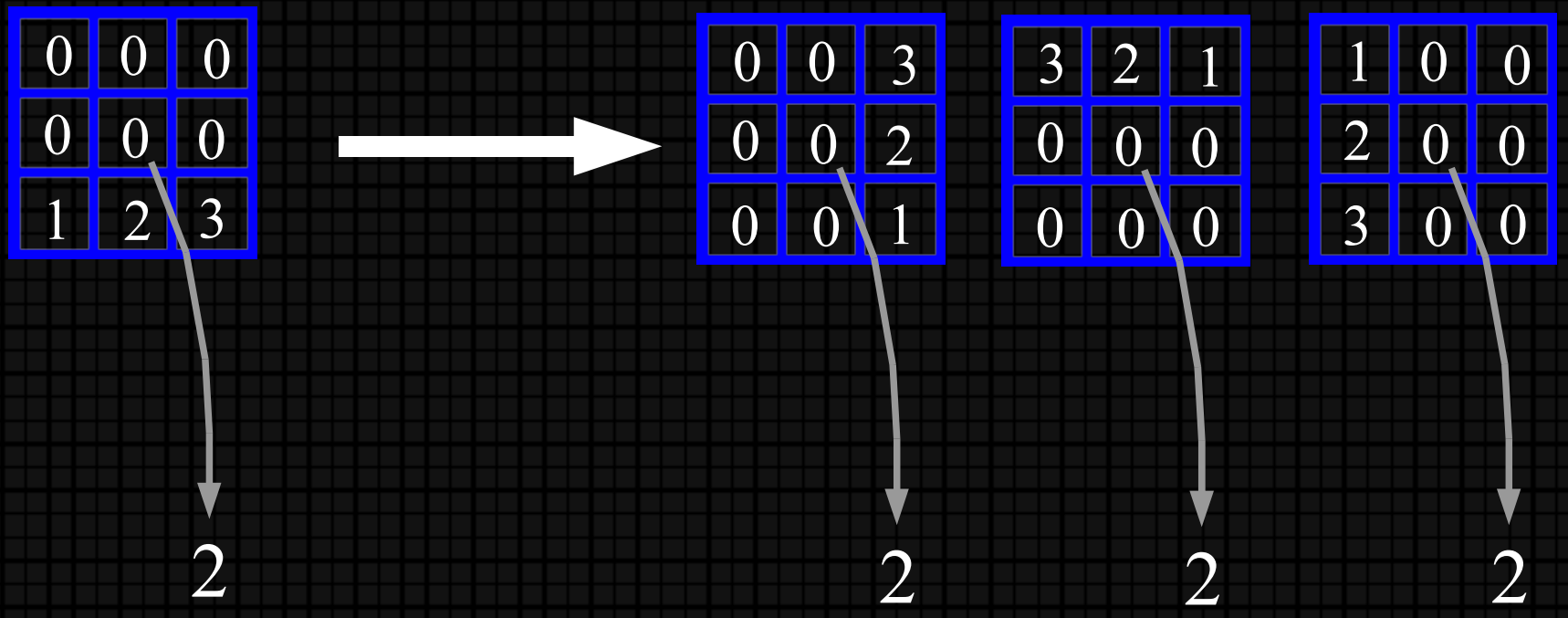
How to evolve cellular automata

0. Start with some initial rule.
1. Make some copies of the CA and change some entries in the transition function tables of the copies.
2. Initialize the original CA and the mutated CA with some predefined or random cell pattern.

   The **difference in the transition rules** can now be seen as **differences in the development** of the cell patterns.
3. Select the most interesting CA.
4. goto 1

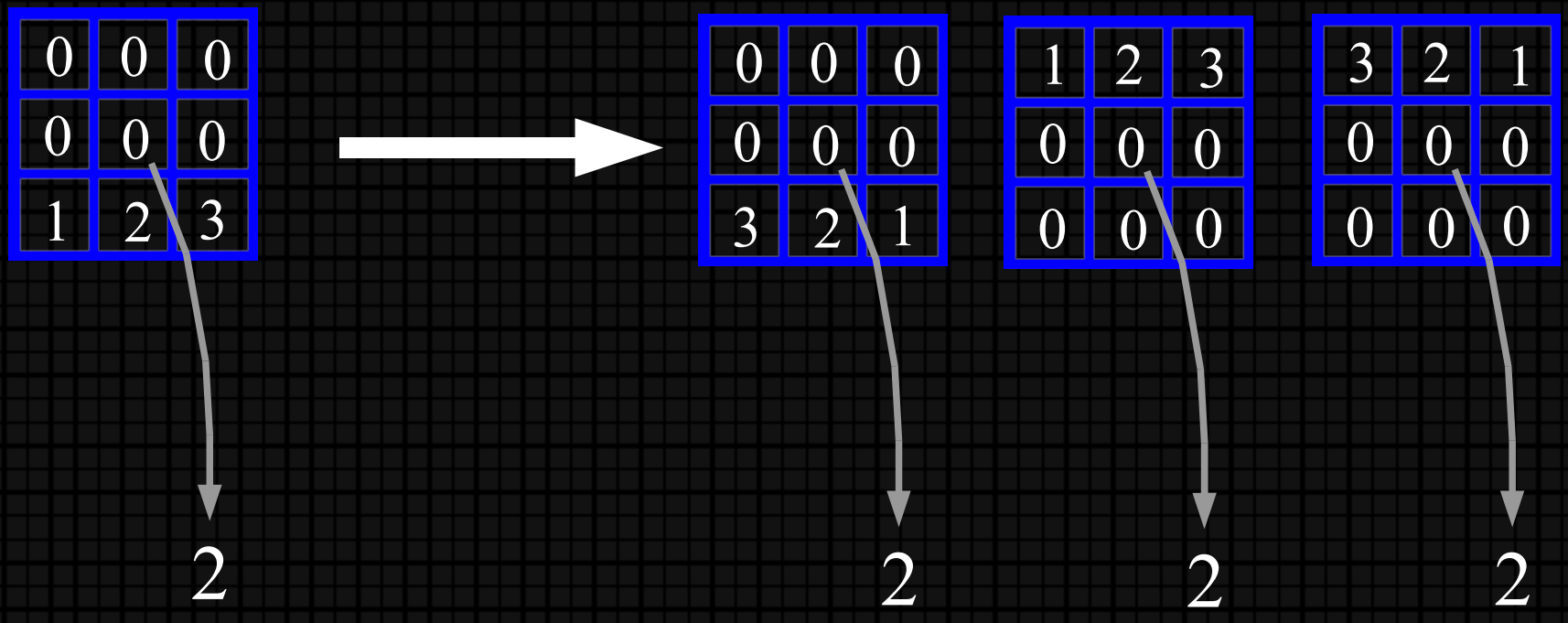
Symmetries

- Rotational Symmetry
- Rotated versions of the same neighbourhood have the same target state
- Example:



Symmetries

- Mirror Symmetry
- Mirrored versions of the same neighbourhood have the same target state
- Example:

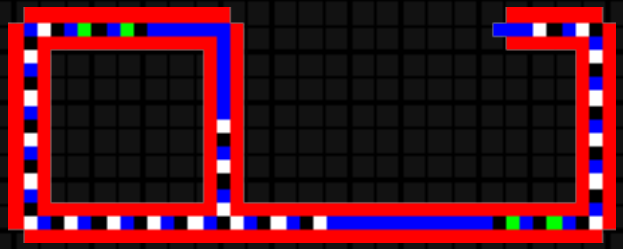


EvoCell Demo

„Regular Expressions“ for Rules

- ? matches any state
- n0, n1, ..., nn matches the nth neighbour
  - n0 + 1 works too
- avg5 matches (sum of all neighbour cells + 5)/n

Evoloop



- CA created by by Hiroki Sayama
  - http://necsi.org/postdocs/sayama/sdsr/
- Self replicating Structure
- „DNA“ inside the loop
  - „DNA“ is copied
  - „DNA“ codes for one side of the loop - fractal
- Loops that collide and become dysfunctional dissolve to free the space
- Loops evolve
  - Smaller loops can reproduce faster

Artificial Life in CA

- Everything is the result / emergent property of local rules
- shows evolution without:
  - Concept of individuals
  - Fitness function
    - select the N fittest individuals
  - Hardcoded genetic algorithm
- EvoLoop is an existence proof for Alife in CA

Resume

- There is a huge space of possible CA
- Presented tools for exploring this space
- “Existence proof“ that there are some interesting points in this space
- Hope I got you interested in CA
- http://kybernet.org/wiki/EvoCell

Thats it!

Questions?

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Huge space of possible CA

- How many CA with **n** neighbours and **s** states are there?
- There are **s^n** different possible combination of states in the neighbourhood
- For each of these **s^n** neighbourhoods we can assign one of **s** target states.
- So there are **s^(s^n)** different possible CA
- This is a huge number!
- How do we find the interesting ones?