Autonomous Intelligent Systems,
Institute for Computer Science VI, University of Bonn

Dr. N. Goerke
Friedrich-Ebert-Allee 144, 53113 Bonn, Tel: (0228) 73-4167
E-Mail: goerke@ais.uni-bonn.de
www.ais.uni-bonn.de

Exercises for Artificial Life (MA-INF 4201), SS11

Exercises sheet 2, due: Mon 2.05.2011

18.4.2011

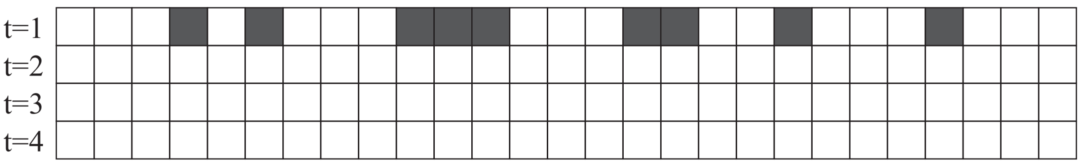
Group	Name	11	12	13	14	15	16	17	18	$\sum$

Assignment 11 (2 Point)

A rule of a Cellular Automaton can be visualized as a table.
Depict the tables for the (*d=1,r=1,k=2*) rules defined by the following (decimal) Wolfram Numbers, and classify for each rule if it is *legal, symmetric, totalistic, or peripheral*:
`( 0, 17, 42, 51, 110, 165, 204, 243 ).`
Your solution shall show, how the Wolfram number and the table are connected to each other.

Assignment 12 (4 Point)

The Cellular Automaton for *d=1, r=2, k=2* (light cells are equal to 0, dark cells are equal to 1) works as following: the content of a cell $a_i(t)$ shall be 1 if the neighborhood in time step $(t-1)$ has exactly 2 or 3 cells that are set.
Please give the respective table for the rule, and calculate the rule-number following the notation of Wolfram (for 1-dim CAs).
Remark: for totalistic rules table and Wolfram number can refer to the sum of cells set.
Please complete the diagram for the time steps $t = 2$ to $t = 4$.
Cells that are not depicted (left, right border) have the content 0.



Assignment 13 (2 Point)

Create a list of Wolfram numbers for all *d=1, r=1, k=2* CA rules that are leagl.

Assignment 14 (2 Point)

Imagine you would have to explain the 4 behaviours of CAs (Wolfram's classification) to someone who has not listened to the Artificial Life lecture and no experience in cellular automata.
Name these 4 behaviours of CAs (Wolfram's classification) and describe their characteristics in your own words (maximum two sentences each).

Assignment 15 (1 Point)

What class of behaviour (Wolfram's classification) is the *r-pentomino* realizing in *Conway's Game of Life* ?
Support your answer with scientific arguments.

Assignment 16 (1 Point)

Depict the *Conway's Game of Life* pattern *Glider* moving to the upper left, for 5 subsequent time steps.

Assignment 17 (1 Point)

Is the rule for *Conway's Game of Life* a totalistic rule?

Assignment 18 (2 Points)

What is the smallest possible configuration for *Conway's Game of Life* (i.e., using the fewest number of living cells) that will completely die out in a single update?
To make this question nontrivial, at least one cell must die from overcrowding (from having four or more neighbors).
(*Adopted from Problems 1.1, C. Adami, Introduction to Artificial Life, Springer 1999*).

Exercise sheet 2: Benedikt Waldvogel, Jaana Takis

Assignment 11

Rule 0: symmetric, legal, peripheral, totalistic

Pattern	111	110	101	100	011	010	001	000
Rule	0	0	0	0	0	0	0	0

Rule 17:

Pattern	111	110	101	100	011	010	001	000
Rule	0	0	0	1	0	0	0	1

Rule 42:

Pattern	111	110	101	100	011	010	001	000
Rule	0	0	1	0	1	0	1	0

Rule 51: symmetric

Pattern	111	110	101	100	011	010	001	000
Rule	0	0	1	1	0	0	1	1

Rule 110:

Pattern	111	110	101	100	011	010	001	000
Rule	0	1	1	0	1	1	1	0

Rule 165: symmetric, peripheral

Pattern	111	110	101	100	011	010	001	000
Rule	1	0	1	0	0	1	0	1

Rule 204: symmetric, legal

Pattern	111	110	101	100	011	010	001	000
Rule	1	1	0	0	1	1	0	0

Rule 243:

Pattern	111	110	101	100	011	010	001	000
Rule	1	1	1	1	0	0	1	1

Assignment 12

Totalistic rule table for the given CA:

SUM(t)	5	4	3	2	1	0
$a_i(t+1)$	0	0	1	1	0	0

Wolfram notation for the totalistic rules table: $1100_B = 12_D$

1			0	0	0	1	0	1	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0
2			0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0
3			0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
4			0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0

Assignment 13

Due to the rules being symmetric, we know that the following pairs must have the same values: 110 and 001, 100 and 001. Since a legal rule must have a silent state 000 = 0 at all times, we can write out the possible known combinations for the above-mentioned triples so far:

Pattern	111	**110**	101	**100**	**011**	010	**001**	**000**
		1		1	1		1	0
		1		0	1		0	0
		0		1	0		1	0
		0		0	0		0	0

To deduce all of the legal rules, we need to apply all possible combinations for the remaining 111, 101, 010. This is the complete selection of legal rules:

Pattern	**111**	110	**101**	100	011	**010**	001	000
Rule 254	1	1	1	1	1	1	1	0
Rule 236	1	1	1	0	1	1	0	0
Rule 182	1	0	1	1	0	1	1	0
Rule 164	1	0	1	0	0	1	0	0
Rule 250	1	1	1	1	1	0	1	0
Rule 232	1	1	1	0	1	0	0	0
Rule 178	1	0	1	1	0	0	1	0
Rule 160	1	0	1	0	0	0	0	0
Rule 222	1	1	0	1	1	1	1	0
Rule 204	1	1	0	0	1	1	0	0
Rule 150	1	0	0	1	0	1	1	0
Rule 132	1	0	0	0	0	1	0	0
Rule 218	1	1	0	1	1	0	1	0
Rule 200	1	1	0	0	1	0	0	0
Rule 146	1	0	0	1	0	0	1	0
Rule 128	1	0	0	0	0	0	0	0
Rule 126	0	1	1	1	1	1	1	0
Rule 108	0	1	1	0	1	1	0	0
Rule 54	0	0	1	1	0	1	1	0
Rule 36	0	0	1	0	0	1	0	0

Rule 122	0	1	1	1	1	0	1	0
Rule 104	0	1	1	0	1	0	0	0
Rule 50	0	0	1	1	0	0	1	0
Rule 32	0	0	1	0	0	0	0	0

Rule 94	0	1	0	1	1	1	1	0
Rule 76	0	1	0	0	1	1	0	0
Rule 22	0	0	0	1	0	1	1	0
Rule 4	0	0	0	0	0	1	0	0

Rule 90	0	1	0	1	1	0	1	0
Rule 72	0	1	0	0	1	0	0	0
Rule 18	0	0	0	1	0	0	1	0
Rule 0	0	0	0	0	0	0	0	0

Assignment 14

I homogeneous – a settling of states over time to one stable, homogeneous state, ie. all cells will have the same state after some time.

II periodic – a pattern that is repetitive in time, eg. same pattern every x steps.

III chaotic – a pattern that seems random to a human observer, ie. there seems to be no distinguishable pattern that we can recognise (there might be, but a human cannot reasonably determine its existence).

IV complex patterns – a subcategory of a chaotic pattern with the distinction that there is a pattern a human can recognise despite the seeming randomness. The pattern seems to be self-organising.

Assignment 15

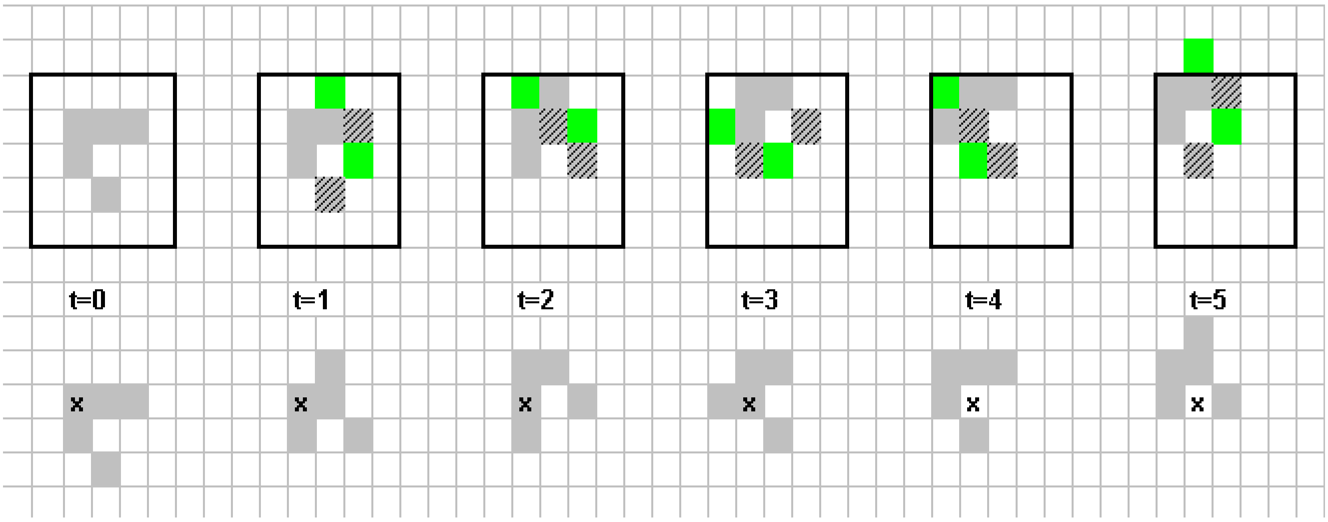
R-pentomimo takes 1103 generations before it settles into a stable state, by that time it consists of just gliders and oscillators, and it is clear that the gliders will never collide with each other or with any oscillators.

We would classify it as class IV based on the following:
- initial patterns evolve into structures that interact in complex and interesting ways
- class 2 type stable or oscillating structures may be the eventual outcome, but the number of steps required to reach this state may be very large, even when the initial pattern is relatively simple
- is capable of universal computation.

Resource: http://en.wikipedia.org/wiki/Cellular_automaton#Wolfram_classes

Assignment 16

Conway's Game of Life: Glider moving to the upper left



Assignment 17

The rule of Conway's Game of Life is not totalistic as the rules depend also on the cell's own state. Eg. If a living cell has a 2 living neighbours, it stays live but if a dead cell has 2 living neighbours, it stays dead. However, Conway's Game of Life is sometimes called outer totalistic (distinction not always made) due to the dependence of the rule on the cell's own state.

Assignment 18

Smallest possible configuration for death after 1 iteration in Conway's Game of Life (where at least 1 cell dies out of overcrowding) has 9 living cells.