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

Exercises sheet 1, due: Mon 18.04.2011

11.4.2011

Group	Name	1	2	3	4	5	6	7	8	9	10	Σ

Assignment 1 (1 Point)

What is the major difference between *Weak Artificial Life* and *Strong Artificial Life*?

Assignment 2 (1 Point)

Where, and when is the next conference on Artificial Life?
Who is organising the conference?
Give the URL of the website with the information on it.

Assignment 3 (1 Point)

Name and describe a definition of *live* or *living* that has not been named during the lecture. Please cite the publication where you have found the definition in a scientific way.

Assignment 4 (1 Point)

Imagine a robot that is moving and acting in a special environment, and that is searching for depots of material, then incorporate the parts found there to recharge the own energy reservoir, and to use these materials to repair smaller damages of the robot.
The main task of the robot would be to build a copy of it's own, out of the ressources provided, and to switch this new robot on.

Would you (personally) judge such a robot as beeing *alive*?

Assignment 5 (3 Points)

Give the four to six criteria that you find to be most feasable to distinguish *living* from *non living*. Explain your decision.

Assignment 6 (3 Points)

Try to sort the following items with respect to their property of beeing a living item according to one of the definitions (either from the lecture or from assignment 5):

Yeast, English language, DNA-sequence, protozoa, river rhine, car, wodden chair, mule, colonie of ants, a tornado, the plasmodium causing malaria, a dried pea, lettuce from the mensa, C++ compiler, hinny .

Assignment 7 (1 Point)

How long would it take to print all Z possible rules for a 1-dimensional CA for the case $k = 4$ and $r = 1$ if you can manage to print 100 rules per second?
Please argue using a formula for the number Z of possible rules with respect to the neighborhood radius r and the number of states k.

Assignment 8 (1 Point)

Prove or disprove the following sentence for 1-dim, $k = 2$, cellular Automata:
If a rule is symmetric, it must be a legal rule that has at least one silent state.

Assignment 9 (1 Point)

Find and name a simulation tool for 1-dimensional cellular automata, that is operating under Unix/Linux, or Windows, or one that is operating from a web browser.
Give detailed web address, and your personal comments to the simulation tool.

Assignment 10 (2 Point)

Develop and implement a formula for a classical spreadsheet program that implements the 1-dimensional cellular automaton with: $d = 1, k = 2, r = 1$, totalistic rule $\mathbf{150}_D$, (Rule number following the Wolfram notation) and print the result for at least 20 timesteps.

Artificial Life
Exercise 1

Jaana Takis, Benedikt Waldvogel

April 15, 2011

Assignment 1

The major difference between *Weak* and *Strong* Artificial Life is that for Strong Artificial Life non-living material is used to construct "real" life. That was never successfully achieved so far. Weak Artificial Life, however, means that life is only simulated. It doesn't really exist in space.

Assignment 2

The next Artificial Life conference is now, from April 13th to April 15th in Paris, France. The IEEE ALIFE 2011 (`http://coco.binghamton.edu/ieee-alife2011/`) is organized by the IEEE Computational Intelligence Society. It's sticking out that Wolfram Research seems to be the main sponsor.

Assignment 3

Ruiz-Mirazo et al. propose a definition of life that has an interesting definition of autonomy. They understand an autonomous system to be in a "far-from-equilibrium" state while being able to maintain itself and to interact with the environment.

> 'a living being' is any autonomous system with open-ended evolutionary capacities, where
>
> i. by autonomous we understand a far-from-equilibrium system that constitutes and maintains itself establishing an organizational identity of its own, a functionally integrated (homeostatic and active) unit based on a set of endergonic-exergonic couplings between internal self-constructing processes, as well as with other processes of interaction with its environment, and

ii. by open-ended evolutionary capacity we understand the potential of a system to reproduce its basic functional-constitutive dynamics, bringing about an unlimited variety of equivalent systems, of ways of expressing that dynamics, which are not subject to any predetermined upper bound of organizational complexity (even if they are, indeed, to the energetic-material restrictions imposed by a finite environment and by the universal physico-chemical laws).

[RMPM04, chapter 4]

Assignment 4

The robot fulfills a lot of the common criteria for life like:

- Existence in space and time
- Reproduction
- Movement out of itself
- Reaction as a consequence to the environment
- Storage of information about oneself[1]

On the other hand, some important criteria are not fulfilled:

- Metabolism
- Evolution

So we would personally rather *not* judge such a robot as being alive.

Assignment 5

1. "Existence in space and time" is obviously the most important criteria for us to distinguish between living from non-living. We would never call imaginary things to be real life.
2. "Evolutionary development" is the second most important criteria for us since all natural life forms have it in common. It's very fascinating since it's so hard to imitate.
3. "Reproduction" is the third most important criteria for almost the same reason as "Evolutionary development". It's very hard to get it right. Actually we've only seen very simplistic approaches so far (eg. MakerBots)
4. "Autonomy" as in [RMPM04] is the fourth most important criteria for us. In our opinion it's important that a living system is able to maintain itself without major exterior influence.

[1] The robot knows how to reproduce himself.

Assignment 6

Our subjective sorting from living to non-living:

1. Mule
2. Hinny
3. Colony of ants
4. Lettuce from the mensa
5. Protozoa
6. The plasmodium causing malaria
7. A dried pea
8. Yeast
9. DNA-sequence
10. A tornado
11. River rhine
12. Car
13. Wooden chair
14. C++ compiler
15. English language

Assignment 7

The size of the neighbourhood is $n = 2 * r + 1 = 3$. Since there are $k = 4$ states, one rule has the size $k^n = 4^3 = 64$. Each mapping of the rule might have k different states. So in total, there are $k^{k^{2*r+1}} = 4^{64} = 340282366920938463463374607431768211456$ rules possible.

Given that an average Gregorian year has about 31556952 seconds (365.2425 days), it would take

$$\frac{1}{100} * \frac{4^{64}}{31556952} \approx 1.078 * 10^{29} years$$

to print all rules, which is roughly $7.5 * 10^{18}$ times the assumed age of the universe.

Assignment 8

The sentence is not true. A symmetric rule need not have a silent state.

Assignment 9

A list of cellular automata simulators can be found on http://cafaq.com/soft/index.php.

One Java based simulator that runs in most modern Web browsers is called Cellsprings/Web - The New Isle Ex CA Explorer (http://jmge.net/java/csprings/).

Our general impression is that simulating software in that area is rather antiquated and from the last century.

A nice way to print Wolfram rules is to use http://www.wolframalpha.com. A query for "cellular automaton rule 90" shows different plots (see Figure 1) and even a generating function.

Assignment 10

$$\mathbf{150}_D = 2^7 + 2^4 + 2^2 + 2^1 = \mathbf{10010110}_B$$

So the rule representation in a table is as follows:

$a_{i-1}(t)$	$a_i(t)$	$a_{i+1}(t)$	$a_i(t+1)$
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

Table 1: Table visualization of rule 150.

One can see that $a_i(t+1)$ is 1 if and only if the sum of the neighbourhood cells is 1 or 3. So there's a simple formula to generate it:

$$a_i(t+1) = \left(\sum_{x=-1}^{1} a_{i+x}(t) \right) \bmod 2$$

This formula can be easily expressed in any spreadsheet program (see Figure 2).

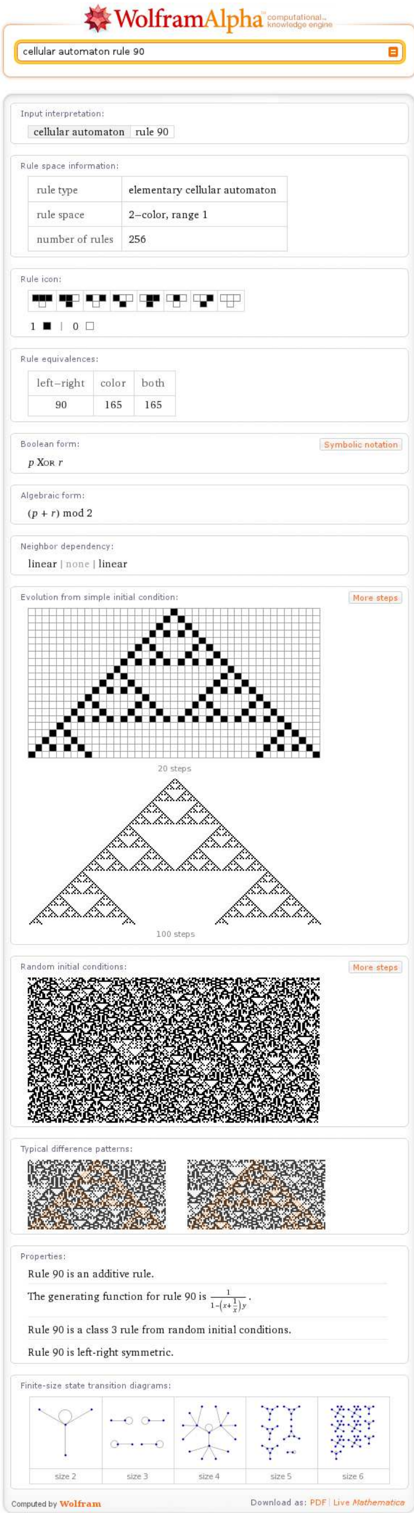
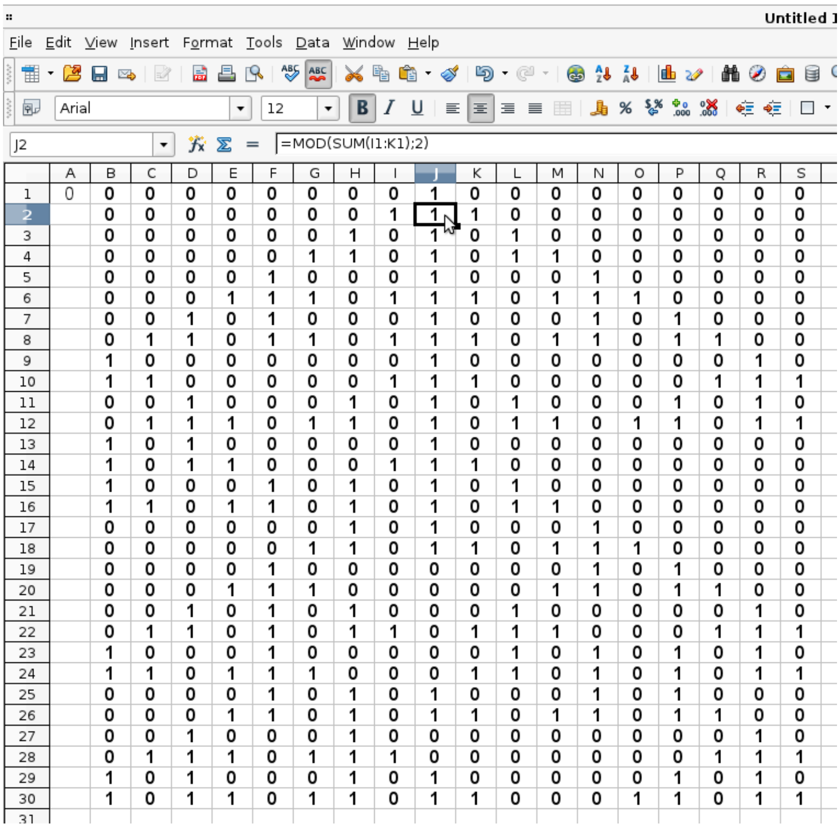


Figure 1: Screenshot of http://www.wolframalpha.com



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2		0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
3		0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0
4		0	0	0	0	0	1	1	0	1	0	1	1	0	0	0	0	0	0
5		0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0
6		0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0
7		0	0	1	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0
8		0	1	1	0	1	1	0	1	1	1	0	1	1	0	1	1	0	0
9		1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
10		1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1
11		0	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0	1	0
12		0	1	1	1	0	1	1	0	1	0	1	1	0	1	1	0	1	1
13		1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
14		1	0	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0
15		1	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0
16		1	1	0	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0
17		0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0
18		0	0	0	0	0	1	1	0	1	1	0	1	1	1	0	0	0	0
19		0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0
20		0	0	0	1	1	1	0	0	0	0	0	1	1	0	1	1	0	0
21		0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0
22		0	1	1	0	1	0	1	1	0	1	1	1	0	0	0	1	1	1
23		1	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	1	0
24		1	1	0	1	1	1	0	0	0	1	1	0	1	0	1	0	1	1
25		0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	0	0	0
26		0	0	0	1	1	0	1	0	1	1	0	1	1	0	1	1	0	0
27		0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
28		0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	1	1	1
29		1	0	1	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0
30		1	0	1	1	0	1	1	0	1	1	0	0	0	1	1	0	1	1
31																			

Figure 2: Screenshot of rule 150 in a spreadsheet program with a simple initial condition.

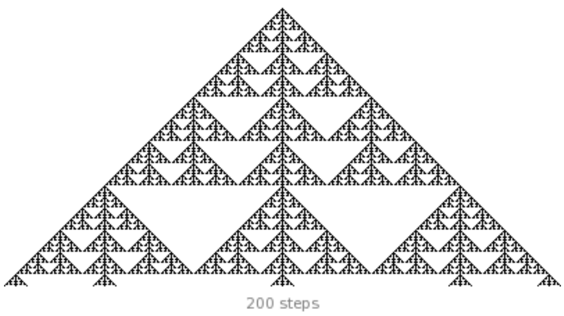


Figure 3: Graphical representation of 200 steps of rule 150 with a simple initial condition.

References

[RMPM04] K. Ruiz-Mirazo, J. Peretó, and A. Moreno. A universal definition of life: autonomy and open-ended evolution. *Origins of Life and Evolution of Biospheres*, 34(3):323–346, 2004.