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

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

Exercises sheet 4, due: Mon 16.05.2011

9.5.2011

Group	Name	24	25	26	27	28	Σ

Assignment 24 (3 Points)

Propose and specify a change to Langton's Loop that will result in a loop with the double length of the edges.

Assignment 25 (3 Points)

Explain how *Chou-Reggia's Loop* is reproducing itself.
Depict the development of the first 6 steps of *Chou-Reggia's Loop*.

Assignment 26 (2 Points)

Take the example (Child, Adult) of a Lindenmeyer System from the lecture (Mon 9th May 2011) and prove that the number of symbols, or the length of the string produced, is generating the Fibonacci numbers.
A *simulation* is not sufficient to prove this.

Assignment 27 (4 Points)

Create four Lindenmeyer systems (rules, alphabet, axiom, ...) and depict the results.
(Do not take examples from the lecture).
a) A Lindenmeyer system that is creating a spiral in 2 dimensions. Please state how the length and the shape of the spiral can be adjusted, plot the result in a graph.
b) A Lindenmeyer system (2-dim) that crates a shape resembling a natural looking tree.
c) A Lindenmeyer system (2-dim) that crates a shape resembling a natural looking bush.
d) A Lindenmeyer system that implements a 4 bit gray coding.

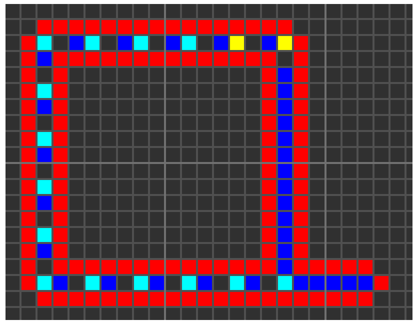
Assignment 28 (3 Points)

Create, and specify a Lindenmeyer System with exactly three rules that will create in step 5 the 32 symbol string shown below, starting with the Axiom `X` in step 0:

Step 5: `XYYZYZZXYZZXZXXYYZZXZXXYZXXYXYYZ`

Artificial Life - Exercise 4
Jaana Takis, Benedikt Waldvogel

Assignment 24
The following initial configuration of Langton's Loop will generate a Langton Loop with double the length of edges.



The channel of the loop is filled with a message for self-replication, consisting of 16 messages separated by „1“s, 14 times 70 (for building edges), followed by 2 times 40 (for building left-hand corners). Fixed arm length of 5 assures that the distance between mother-daughter loops will not be more than 1 cell – necessary property for continuous self-replication.

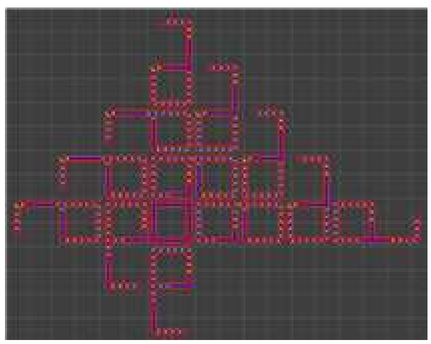


Figure - Double-length Langton's Loop after 1390 generations

Assignment 25
There are two variants of the Chou Reggia’s loop. One has an initial size of 5 cells, the other has an initial size of 6 cells. For this assignment we use the latter variant.

Chou Reggia’s loop is basically a minimized version of Langton’s loop that has no sheath cells. Figure 1 and 2 depict the first 10 generations of the loop.

Figure 1: Generation 0 - 4 of a Chou-Reggia’s Loop

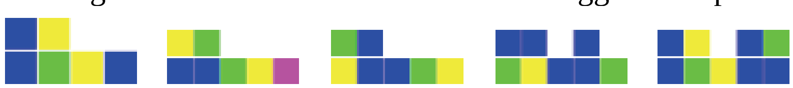


Figure 2: Generation 5 - 9 of a Chou-Reggia’s Loop

Cells in the state 4 (yellow) and 3 (green) rotate counter-clockwise on a 4*4 cube in the state 1 (blue). Similar to Langton’s loop there’s an arm at the bottom right. After roughly 13 generations the loop reproduced itself and two individual loops continue reproducing etc. (see Figure 3).

In figure 6 one can see the diamond pattern that consists of 4*4 cubes. The reproducing only happens at the boundaries and the inner cubes are stable.

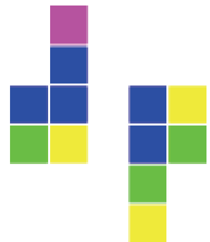


Figure 3: Generation 16 of a Chou-Reggia's Loop

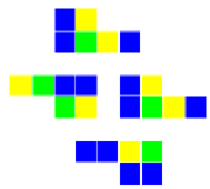


Figure 4: Generation 28 of a Chou-Reggia's Loop

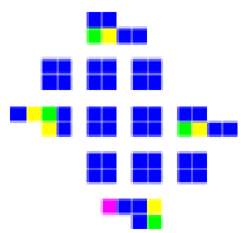


Figure 5: Generation 58 of a Chou-Reggia's Loop

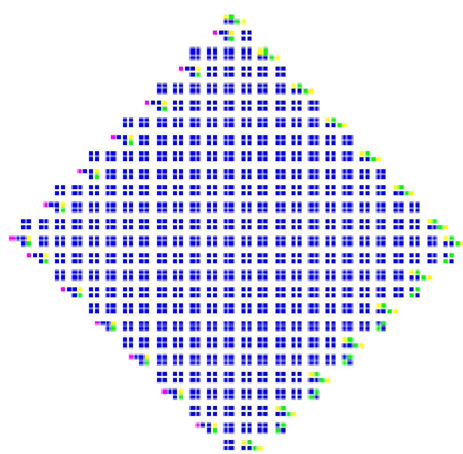


Figure 6: Generation 353 of a Chou-Reggia's Loop

Assignment 26

Fibonacci numbers are defined as following:

$$F_n = F_{n-1} + F_{n-2} \quad \text{for} \quad n \geq 2$$
$$F_0 = 1 \quad \text{and} \quad F_1 = 1$$

In the case of the Lindenmeyer example, the size can be calculated as following if L is the number of symbols in the system, C is the number of children and A is the number of adults:

$$L_n = C_n + A_n \tag{1}$$

(1) says that the number of symbols is defined as the number of children and number of adults in the system.

Each adult spawns a new child, so one can also define the following formula:

$$L_n = C_{n-1} + 2 * A_{n-1}$$
$$L_n = \underbrace{C_{n-1} + A_{n-1}}_{L_{n-1}} + A_{n-1}$$
$$L_n = L_{n-1} + A_{n-1} \tag{2}$$

The number of adults can be defined as follows:

$$A_n = A_{n-1} + C_{n-1} \tag{3}$$

(3) says that the number of adults results from the adults in the previous step and the children from the previous step that matured. By putting (3) into (2) under consideration of (1) you get the following:

$$L_n = L_{n-1} + \underbrace{A_{n-2} + C_{n-2}}_{L_{n-2}}$$
$$L_n = L_{n-1} + L_{n-2}$$

We see that this is the same as the definition of the Fibonacci numbers since L0 = L1 = 1.

Assignment 27

a. Spiral
Variables: A,B
Contants: C
Axiom: A
Rule 1: A → B+A
Rule 2: B → CC
The rotation angle is decreased after n steps by 20%.

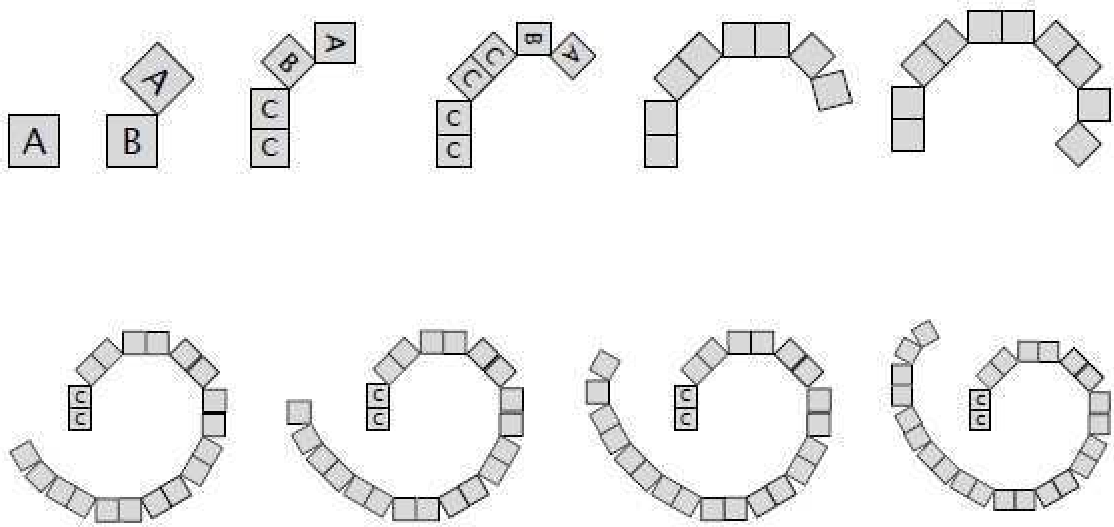


Figure 7: Lindenmeyer Spiral

The length and shape of the spiral can by adjusted by changing rule 2 (e.g. to B → CCC or B → CCCC) and adjusting the parameter by which the angle is decreased after n steps.

b. Tree

Variables: X,F
Axiom: X
Rule 1: X → FF[-X]X[+FX]
Rule 2: F → FF

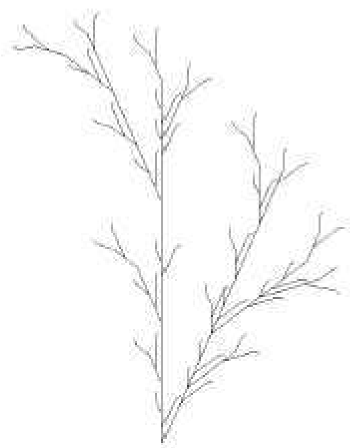


Figure 8: Screenshot of L-Systems Explorer depicting simulation of the tree rule

c. Bush

Variables: X,F
Axiom: X
Rule 1: X → F-[X+FX]-F[+FX]-X
Rule 2: F → FF

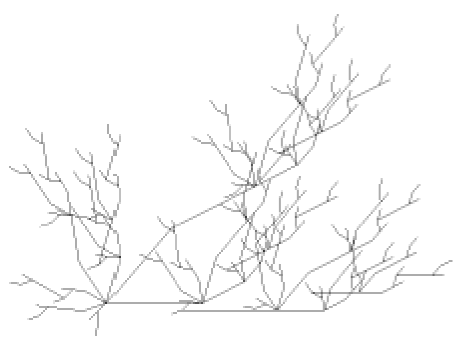


Figure 9: Screenshot of L-Systems Explorer depicting simulation of the bush rule

d. 4-bit gray coding

Variables: F
Axiom: F
Rule 1: F → F=FFFF[FFFF]+F-F[FFFFFF[+F[F+F]-FFF+F-F]F]+F[F-F]+FFF-F+F

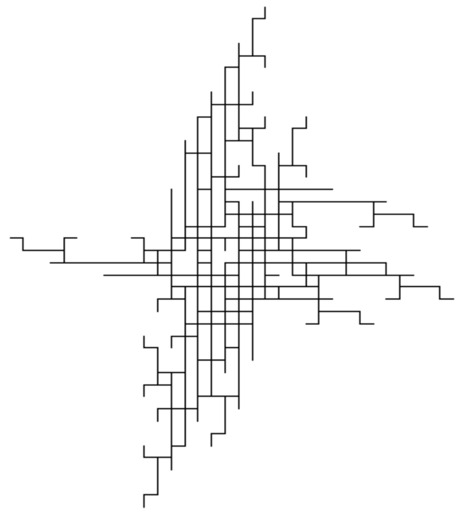


Figure 10: Screenshot of L-Systems Explorer depicting simulation of the 4-bit gray coding pattern

Assignment 28
Variables: X,Y,Z
Constants: None
Axiom: X
Rule 1: X → XY
Rule 2: Y → YZ
Rule 3: Z → ZX

```
0:                    X
1:          X                   Y
2:     X         Y         Y         Z
3:   X   Y     Y   Z     Y   Z     Z   X
4:  XY   YZ   YZ   ZX   YZ   ZX   ZX   XY
5: XYYZ YZZX YZZX ZXXY YZZX ZXXY ZXXY XYYZ
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