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MA-INF 4201 - Artificial Life
Exercise Sheet 4

Assignment 24

A loop with the double length of the edges needs twice more *msg.forward* blocks Each "70" string/message builds one cell. Each "40" string makes a corner/builds a daughter. ⇒ to double length of the edges, you just need to double the edges you just need to double the number of "70" messages, i.e. each 12 and take the same number of "40" strings. ∎

Assignment 25

The reproduction of the *Chou-Reggia*-loop is basically identical to *Langton's loop*, except that in *Chou-Reggia*-loop all sheaths are removed. Instead of the extending arm, a *growth cap* is developed at the tip of the first *msg.forward* blocks. This *growth cap* provides a sense of orientation, replacing the function of the sheaths.

$$t=0: \begin{array}{|c|c|c} \hline 1 & 1 & \\ \hline 3 & 4 & \multicolumn{1}{c|}{1} \\ \hline \end{array} \qquad t=1: \begin{array}{|c|c|c} \hline 1 & 4 & \\ \hline 1 & 3 & \multicolumn{1}{c|}{5} \\ \hline \end{array} \qquad t=2: \begin{array}{|c|c|c|c|} \hline 4 & 3 & 7 & \\ \hline 1 & 1 & 3 & 7 \\ \hline & & 7 & \\ \hline \end{array}$$

$$t=3: \begin{array}{|c|c|c|c|} \hline 3 & 1 & 7 & 7 \\ \hline 4 & 1 & 1 & 2 \\ \hline & & 7 & 7 \\ \hline \end{array} \qquad t=4: \begin{array}{|c|c|c|c|} \hline 1 & 1 & & \\ \hline 3 & 4 & 1 & 1 \\ \hline \end{array}$$

∎

Assignment 26

loop generation 1 : $\begin{array}{ccc} & \cdot & \\ \cdot & \boxed{} & \cdot \\ & \cdot & \end{array}$ loop generation 2 : $\begin{array}{cccc} & \cdot & \cdot & \\ \cdot & \boxed{} & \boxed{} & \cdot \\ & \cdot & \cdot & \end{array}$

Langton's loop reproduces itself in every direction. It is operating in a $2D$ grid. The structure is growing with the same speed in two dimensions. First generation loop can grow into four room directions. Second generation loop can only grow into three room directions. ⇒ the space requirement lies somewhere in the magnitude of $\Theta\left(n^2\right)$. ∎

Assignment 27

Define:

$$\begin{aligned} C(t) &= \text{number of symbols C at timestep t} \\ A(t) &= \text{number of symbols A at timestep t} \\ N(t) &= C(t) + A(t) (\text{length f the string}) \end{aligned}$$

First: Check starting conditions

$$\begin{aligned}
N(0) &\overset{\text{def.}}{=} C(0) + A(0) = 1 + 0 = 1 \\
N(1) &\overset{\text{def.}}{=} C(1) + A(1) \overset{(1)(2)}{=} A(0) + C(0) + A(0) \\
&\overset{\text{Axiom}}{=} 0 + 1 + 0 = 1
\end{aligned}$$

So for $t = 2$ we get:

$$\begin{aligned}
N(t+1) &\overset{\text{def.}}{=} C(t+1) + A(t+1) \\
&\overset{(1)(2)}{=} A(t) + C(t) + A(t) \\
&\overset{\text{def.}}{=} N(t) + C(t-1) + A(t-1) \\
&\overset{(2),\text{def.}}{=} N(t) + N(t-1)
\end{aligned}$$

Where in the above we used:

(1): How are 'C's produced? Only with rule 2 $\Rightarrow C(t+1) = A(t)$

(2): How are 'A's produced? With rule 1 and rule 2: $A(t+1) = C(t) + A(t)$

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Assignment 28

variables:	R, S, T
axiom:	R
rule 1:	$R \rightarrow RS$
rule 2:	$S \rightarrow ST$
rule 3:	$T \rightarrow TR$

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Assignment 29

a) The $B \rightarrow BC$ rule adds one unit length per turn, thus controls the length of the segments. The $A \rightarrow A + BC + BC$ concatenates the turns of the spiral.

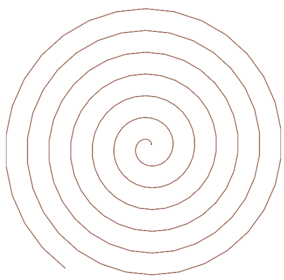
variables:	A, B, C
constants:	+,-
axiom:	-A
rule 1:	$A \rightarrow A + BC + BC$
rule 2:	$B \rightarrow BC$

b)

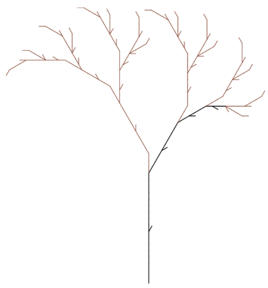
variables:	B, C, D, E, F
constants:	+,-
axiom:	B
rule 1:	$B \rightarrow C[-B]E[+B]$
rule 2:	$C \rightarrow F[-D]F$
rule 3:	$F \rightarrow FF$

c)

variables:	0, 1, X	more than one symbol $\Rightarrow$ context dependent
constants:		
axiom:	X	
rule 1:	$X \rightarrow 0000$	
rule 2:	$0000 \rightarrow 0001$	
rule 3:	$0001 \rightarrow 0011$	
rule 4:	$0011 \rightarrow 0010$	
$\vdots$	$\vdots$	
rule 16:	$1001 \rightarrow 1000$	
rule 17:	$1000 \rightarrow 0000$	



(a) spiral for $\alpha = 12^\circ$, 100 iterations



(b) tree, for $\alpha = 30^\circ$, 5 iterations

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References

[01] Reggia, James A and Chou, Hui-Hsien and Lohn, Jason D: "Cellular automata models of self-replicating systems" published in "Advances in Computers", volume 47, pp. 141–183, *Elsevier*, 1998