**SYSC 5104: Methodologies for Discrete-Event Modeling and Simulation**

**Instructor: Prof. Gabriel A. Wainer**

**Self-Organized 3D Printing Patterns**

**Assignment 2**

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**Part I: Self-Organized 3D Printing Patterns**

3D Printing process creates some self organized patterns due to certain printing conditions. Self organized stochastic patterns can be of two types: (i) a thin unintened string is generated between standing edges and (ii) small chunks of plastic can be seen in the center or at the end of the strings.

For this cellular I have referred to a reference paper Self-organized 3D-printing Patterns Simulated by Cellular Automata by Yasusi Kanada. I have implement one part of the report that is simulating stripes.

The self-organized stochastic patterns can be simulated by cellular automata. The concet is:

In a 3-dimensional space circle is drawn and the values of the cells in upward direction are calculated. The value of each cell is probabilistically decided.

For a cell at layer(l) and position(i)

If cell[l-1] = 1 and probability is p0 then cell[l][i] = 1 (it will check the previous layer cell)

else if cell[l-1][i+1] = 1 and probability is p1 then cell[l][i] = 1 (it will check the next cell)

else cell[l][i] = 0

Previous layer

Current layer

p0

P1

When the rules are processed the cells are set to either (1)on or (0)off. p0 and p1 are the random values that decides the direction of stripes. For different values of p0 and p1 different patterns are generated.

**Part II: Formal Specification**

**Cell-DEVS Atomic Model Specification**

The following is the formal specification for the Cell-DEVS self-organized 3D printing patterns model:

CD = < X, Y, I, S, θ, N, d, δint, δext, τ, λ, D >

X = Ø

Y = Ø

S = { 0, 1 }

N = neighborhood = {(-1,-1,-1), (-1,0,-1), (-1,1,-1), (0,-1,-1), (0,0,-1), (0,1,-1), (1,-1,-1) , (1,0,-1), (1,1,-1), (-1,-1,0) , (-1,0,0) , (-1,1,0) , (0,-1,0) , (0,0,0) , (0,1,0),(1,-1,0) , (1,0,0) , (1,1,0), (-1,-1,1) , (-1,0,1) , (-1,1,1), (0,-1,1) , (0,0,1) , (0,1,1), (1,-1,1) , (1,0,1) , (1,1,1)}

d = 100 ms

τ: N🡪S is defined by the following rules:

S = 1 if cell(0,0,0) = 0 and cell(0,0,-1) = 1 and random <= p0

S = 1 if cell(0,0,0) = 0 and cell(1,0,-1) = 1 and random <= p1

S = 0 for any other condition

**Cell-DEVS Coupled Model Specification**

[Top]

components : 3dprinting

[3dprinting]

type : cell

dim : (20,20,5)

delay : transport

defaultDelayTime : 100

border : nowrapped

neighbors : 3dprinting(-1,-1,-1) 3dprinting(-1,0,-1) 3dprinting(-1,1,-1)

neighbors : 3dprinting(0,-1,-1) 3dprinting(0,0,-1) 3dprinting(0,1,-1)

neighbors : 3dprinting(1,-1,-1) 3dprinting(1,0,-1) 3dprinting(1,1,-1)

neighbors : 3dprinting(-1,-1,0) 3dprinting(-1,0,0) 3dprinting(-1,1,0)

neighbors : 3dprinting(0,-1,0) 3dprinting(0,0,0) 3dprinting(0,1,0)

neighbors : 3dprinting(1,-1,0) 3dprinting(1,0,0) 3dprinting(1,1,0)

neighbors : 3dprinting(-1,-1,1) 3dprinting(-1,0,1) 3dprinting(-1,1,1)

neighbors : 3dprinting(0,-1,1) 3dprinting(0,0,1) 3dprinting(0,1,1)

neighbors : 3dprinting(1,-1,1) 3dprinting(1,0,1) 3dprinting(1,1,1)

initialvalue : 0

initialCellsValue : 3dprinting.val

localtransition : 3dprinting-rule

[3dprinting-rule]

rule : 1 100 { (0,0,0) = 0 and (0,0,-1) = 1 and random <= 0.97 }

rule : 1 100 { (0,0,0) = 0 and (1,0,-1) = 1 and random <= 0.9 }

rule : 0 100 { t }

The initial value of the model is defined by setting the cells to 0 or 1.

(3,6,0) = 1

(3,8,0) = 1

(3,9,0) = 1

(3,10,0) = 1

(3,12,0) = 1

(4,5,0) = 1

(4,13,0) = 1

(5,4,0) = 1

(6,3,0) = 1

(6,15,0) = 1

(7,3,0) = 1

(7,15,0) = 1

(8,3,0) = 1

(8,15,0) = 1

(9,3,0) = 1

(9,15,0) = 1

(10,4,0) = 1

(10,14,0) = 1

(11,5,0) = 1

(11,13,0) = 1

(12,6,0) = 1

(12,7,0) = 1

(12,9,0) = 1

(12,10,0) = 1

(12,11,0) = 1

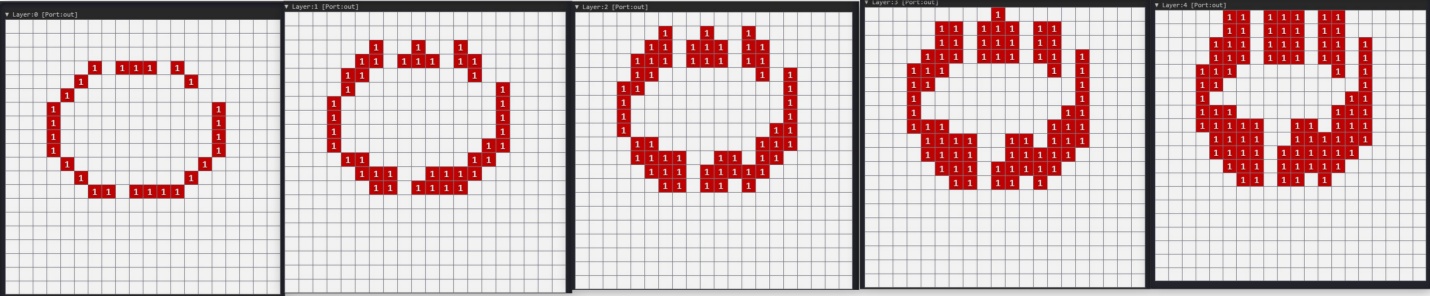
(12,12,0) = 1

**Implementation and Testing**

This model was tested with three different values of the probabilities p0 and p1. Each test was done in separate model files(3dprinting.ma, 3dprinting\_stripes.ma, 3dprinting\_stripes1.ma).

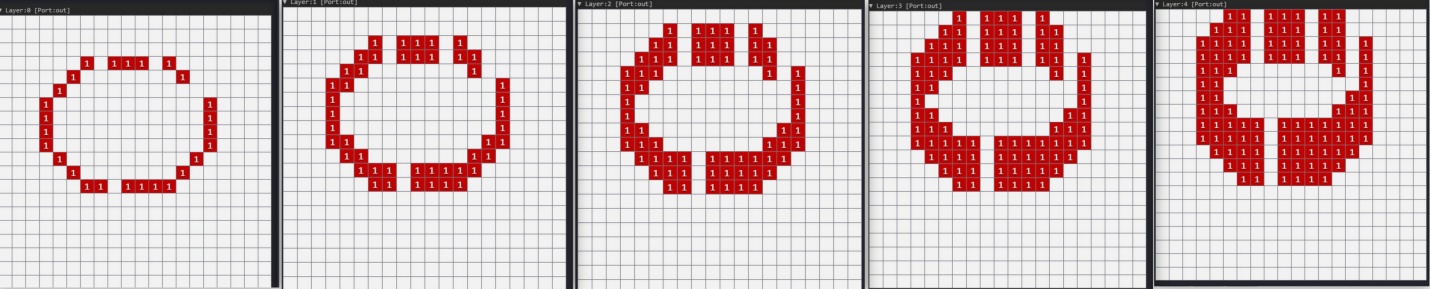
**Model 1:**

This model was tested with the value of p0 = 0.99 and p1 = 0.9. The output was a noisy pattern as shown below:



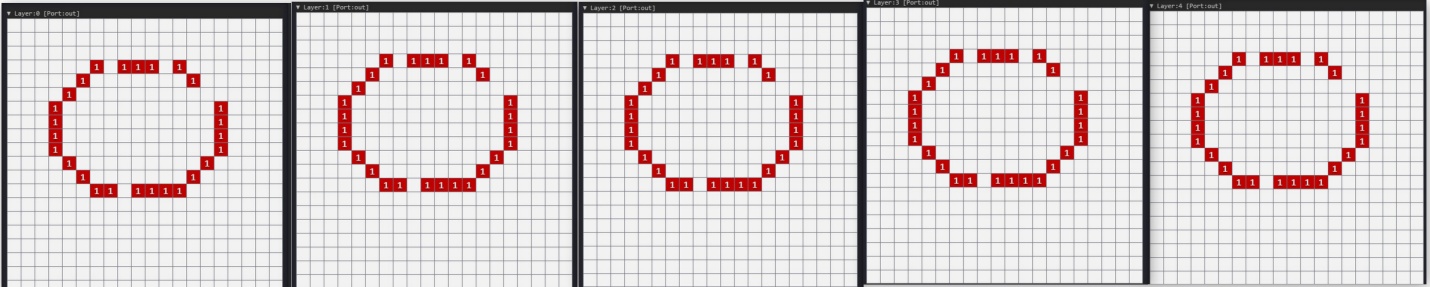
**Model 2:**

The second model was tested with the value of p0 = 0.99 and p1 = 1.0. When p1 = 1.0 crisp stripes are generated as shown below:



**Model 3:**

The third model was tested with the value of p0 = 1.0 and p1 = 0. When p0 = 1.0 vertical stripes are generated:



**References:**

(1.) Kanada, Y: Self-organized 3D-printing Patterns Simulated by Cellular Automata – [Artificial Life and Robotics](http://link.springer.com/journal/10015) December 2014, Volume 19, [Issue 4](http://link.springer.com/journal/10015/19/4/page/1), pp 311–316

(2.) Kanada, Y.: 3D Printing and Simulation of Naturally-randomized Cellularautomata.

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