SYSC-5807
METHODOLOGICAL ASPECTS OF MODELLING AND SIMULATION

Image Generalization Using Cellular Automata

(Assignment 2)

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PART 1 – CONCEPTUAL MODEL

The cell devs model implemented in this assignment is based on the model proposed in the article titled, "Cell-based Model for GIS Generalization" by Bo Li, Graeme G. Wilkinson & Souheil Khadda.

This particular model will take a given picture input and provide a generalized version based on the following algorithm:

For each iteration {
    For every pixel in the image {

        If the cell is the same state as its group made by several adjacent neighbouring cells

            Keep the state of the cell unchanged

        Else choose the majority cells' value

        If the number of cells in each state surrounding the pixel are of equal value

            Keep the state of the cell unchanged
    }
}

The neighbourhood used in the article was an extended Moore neighbourhood. This will also be used in the cell devs implementation and will be varied to try to show the effectiveness of different neighbourhoods on the degree of generalization.

PART 2 – FORMAL SPECIFICATIONS AND SIMULATION STRATEGIES

IMAGE

X = {φ}
Y = {φ}
I = <η, μ, P^x, P^x>

η = 5, the neighbourhood size (This varies with each simulation to show the effect of different neighbourhoods. Other neighbourhood sizes will be of 9 and 25.)

μ = {φ}

P^x = {φ}

P^x = {φ}

S = { Real numbers} where each unique number represents a unique colour
N = { (-1,0), (0,-1), (0,0),(1,0), (0,1) } for η = 5;
= {(-1,-1), (-1,0), (-1,1), (0,-1), (0,0), (0,1), (1,-1), (1,0), (1,1) } for η = 9;
= {(-2,-2), (-2,-1), (-2,0), (-2,1), (-2,2), (-1,-2), (-1,-1), (-1,0), (-1,1), (-1,2), (0,-2), (0,-1), (0,0), (0,1), (0,2), (1,-2), (1,-1), (1,0), (1,1), (1,2), (2,-2), (2,-1), (2,0), (2,1), (2,2) } for η = 25
d = 0
δ_{int} : {φ}
δ_{ext} : {φ}
τ : *For every cell in the image {*

If the cell is the same state as the majority of it's neighbours

Keep the state of the cell unchanged

Else choose the majority cells' value

If the neighbourhood consists of an equal distribution of states

Keep the state of the cell unchanged

}

λ : {φ}
D : 100 ms

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SIMULATION STRATEGY AND RESULTS

The image used in this image generalization simulation is a bitmap of 7 colours. The bitmap was converted to raw data format using Paintshop Pro and then a small java function was created to present the raw data format in a way that CD++ would recognize as a valid format to set the initial values of the cells.

picture.bmp → picture.raw (using Paintshop Pro) → picture.MAP (using java function)

The generalization scheme was simulated using 3 different neighbourhoods:

1:

	(-1,0)	
(0,-1)	(0,0)	(0,1)
	(1,0)	

2:

(-1,-1)	(-1,0)	(-1,1)
(0,-1)	(0,0)	(0,1)
(1,-1)	(1,0)	(1,1)

3:

(-2,-2)	(-2,-1)	(-2,0)	(-2,1)	(-2,2)
(-1,-2)	(-1,-1)	(-1,0)	(-1,1)	(-1,2)
(0,-2)	(0,-1)	(0,0)	(0,1)	(0,-2)
(1,-2)	(1,-1)	(1,0)	(1,1)	(1,-2)
(2,-2)	(2,-1)	(2,0)	(2,1)	(2,-2)

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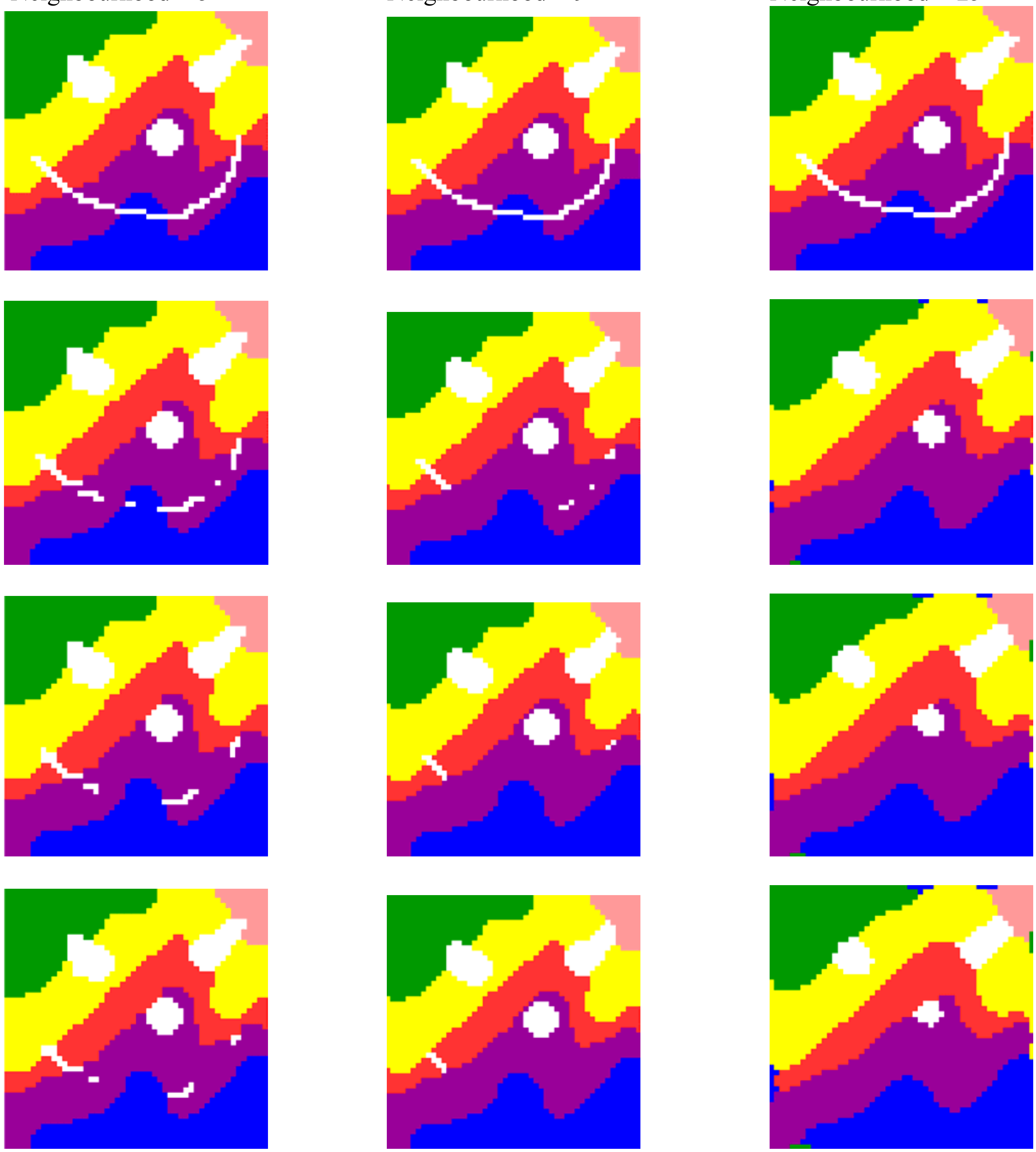
Neighbourhood = 5 Neighbourhood = 9 Neighbourhood = 25



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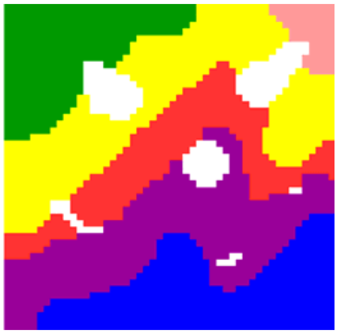
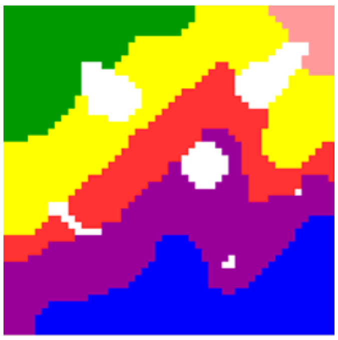
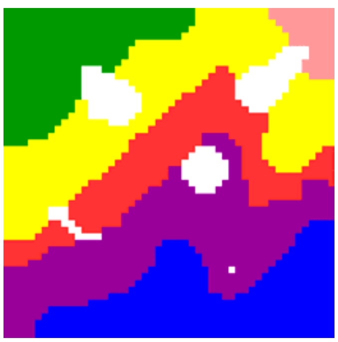
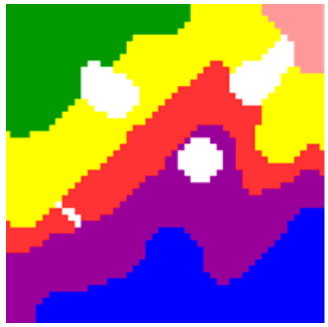
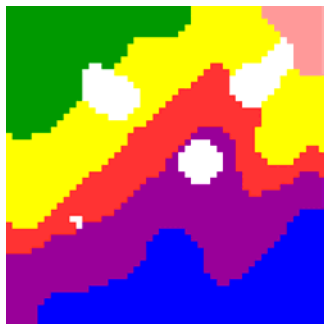
Neighbourhood = 5 cont’d


Neighbourhood = 9 cont’d

Neighbourhood = 25 cont’d

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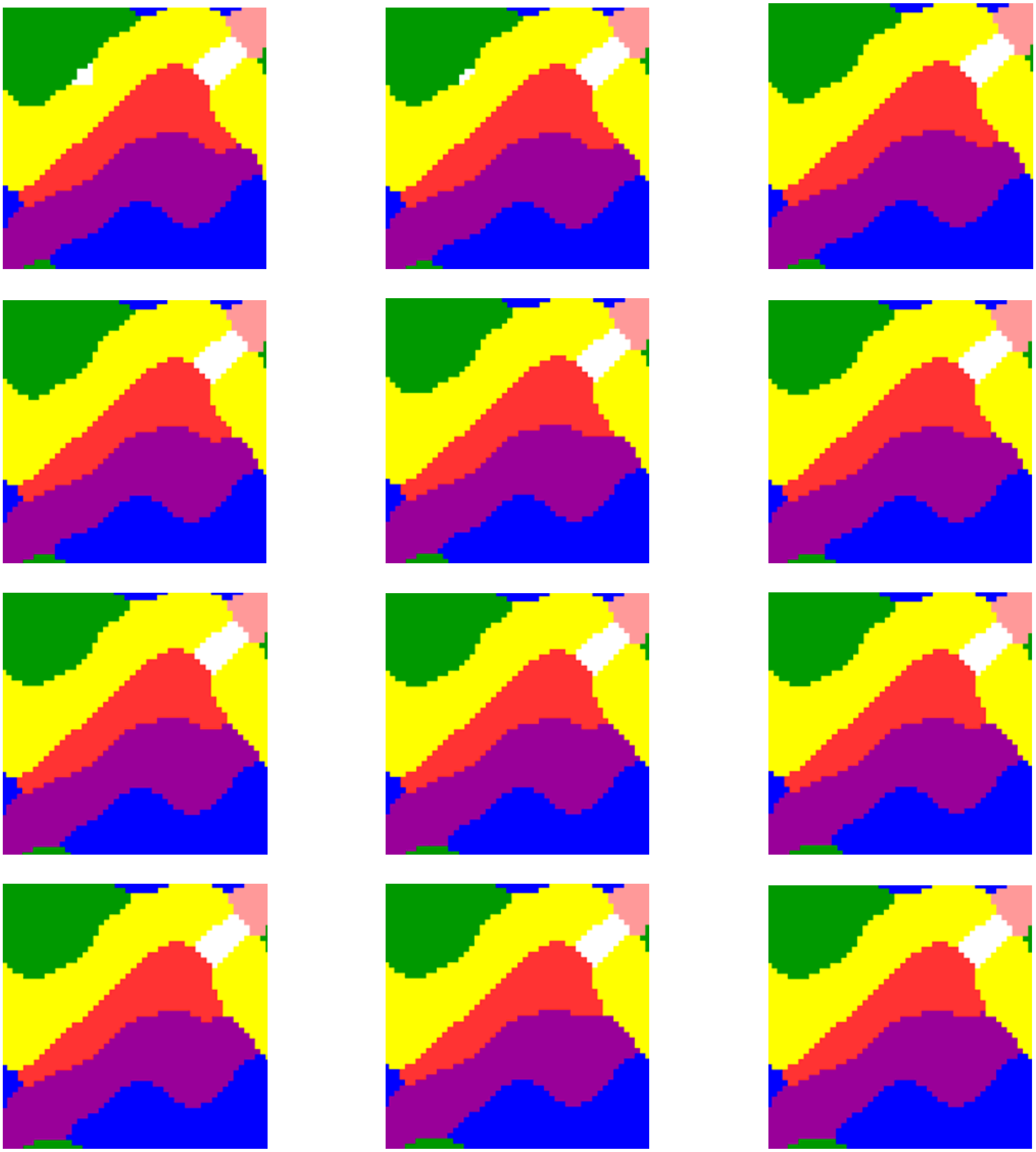
The Extended Moore simulation (neighbourhood = 25) continues on ….



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Simulations show that increasing the size of the neighbourhood increases the degree of generalization. For example, in the simulations depicted above, the 'smiley' face is almost gone when the neighbourhood = 25 and is only missing part of the smile when the neighbourhood = 5. Detail is retained with a smaller neighbourhood. Another observation is that the 'wrapped' boundry is seen in the simulation where the neighbourhood is greater.

Comments:
While experimenting with various bitmaps to use for this assignment, I realized a limitation of the CD++ Modelor tool. When values of the cells were greater than 2 digits, the tool could not differentiate which values belonged to which cells. Due to this limitation, I had to create a bitmap which contained no more than 9 colours

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