Segregation Simulation - Assignment 2

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GitHub Repository

http://www.github.com/arthuratangana/segregation-simulation

1 Part 1

1.1 Introduction

The segregation model was first introduced by Thomas Schelling. His paper describes how populations segregate over time based on their different characteristics. Examples of these characteristics could be age, language, income, sex, and many more. This is the core idea that was implemented in this model and simulation, based on two groups with a distinct characteristic.

1.2 Model

The model consists of two groups: Group A (represented by 1) and Group B (represented by -1). Using a Moore Neighborhood of size 3x3, a cell will look at its neighbours and move to the first empty cell it can find if its current neighborhood has a majority of different cells relative to itself.

Rules

- For every cell with a value of 1, calculate the sum of its 3x3 Moore neighbourhood (excluding the center cell):
  - If $\Sigma < -0.5$, the cell moves to the first available empty cell.
- For every cell with a value of -1:
  - If $\Sigma > 0.5$, the cell moves to the first available empty cell.

States

Value	Meaning
0	Empty Cell
1	Group A
-1	Group B

2 Part 2 - Specification and Implementation

2.1 Cell-DEVS Formal Specification

- $X = \emptyset$
- $Y = \emptyset$
- $S = \{0, 1, -1\}$
- delay = inertial
- N = Moore's 3x3
- $d = 1$
- $\tau =$

```
// Count the number of different-type neighbors
for (const auto& [neighborId, neighborData] : neighborhood) {
    double neighborValue = neighborData.state->value;

    if (neighborValue != 0.0) { // Ignore empty cells
        totalNeighbors++;
        if ((state.value > 0 && neighborValue < 0) || (state.value < 0 && neighborValu
            differentNeighbors++;
        }
    }
}

// Move if more than 50% of non-empty neighbors are different
if (totalNeighbors > 0 && (double)differentNeighbors / totalNeighbors > 0.5) {
    if (state.value == 1.0){
        numA++;
    }
    else if (state.value == -1.0) {
        numB++;
    }
    state.value = 0.0; // The current position becomes empty
}

return state;
```

- $D = 1$
- δ_{int} = Cell-DEVS specification
- δ_{ext} = Cell-DEVS specification
- λ = Cell-DEVS specification

2.2 Test Frames and Experiments

The segregation maps generated using the formal specification above showcase the behavior of the model under different starting conditions.

Experiment 1

Group A moves while Group B is already segregated.

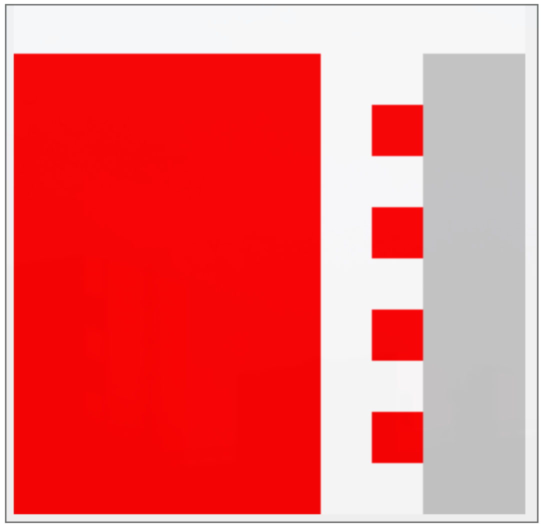

Figure 1: Experiment 1 - Initial State

Figure 2: Experiment 1 - Final State

Experiment 2

Group B moves while Group A is already segregated.

Figure 3: Experiment 2 - Initial State

Figure 4: Experiment 2 - Final State

Experiment 3

Both Group A and B need to move.

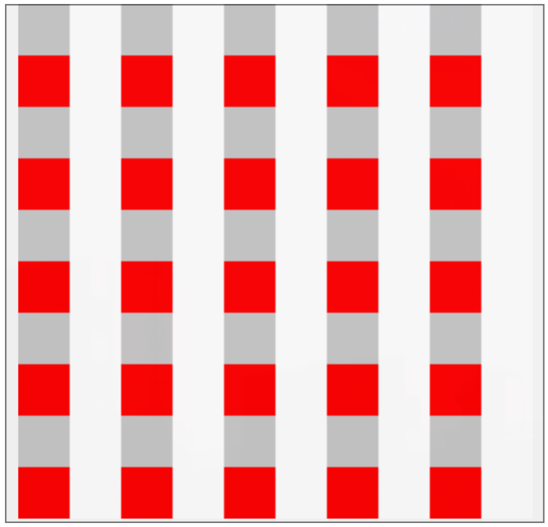

Figure 5: Experiment 3 - Initial State

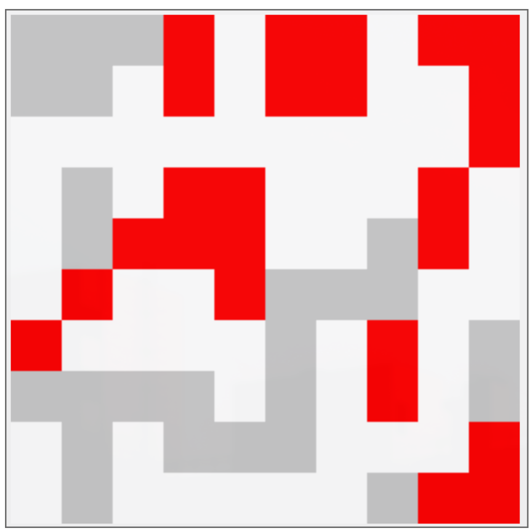

Figure 6: Experiment 3 - Final State

Experiment 4

Only one valid spot exists for a Group A cell.

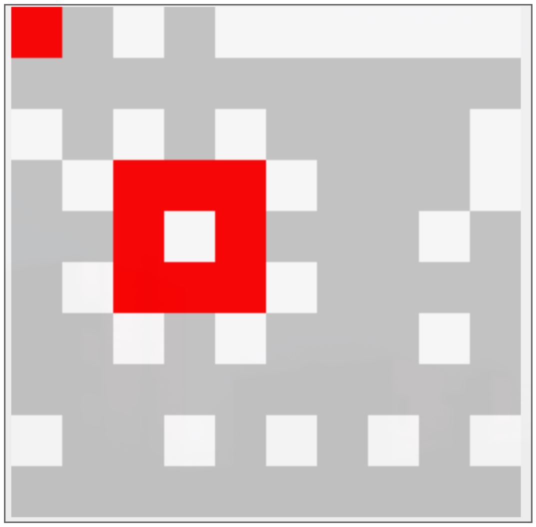

Figure 7: Experiment 4 - Initial State

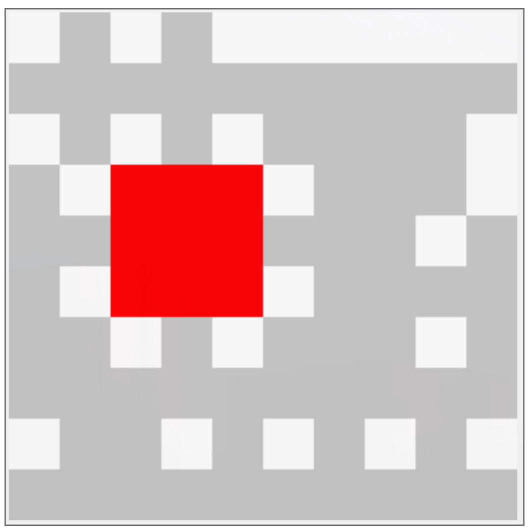

Figure 8: Experiment 4 - Final State

Experiment 5

No valid spot exists for the Group A cell.

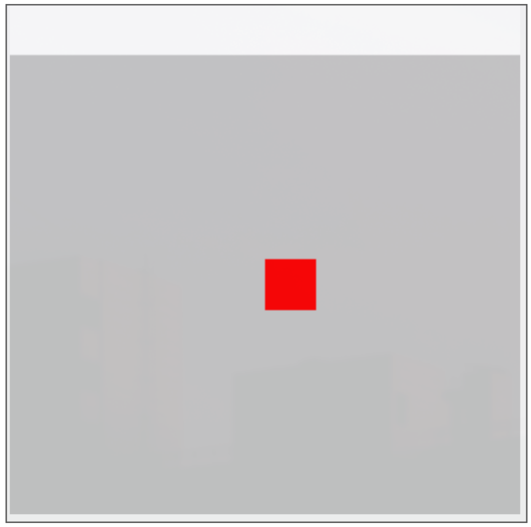

Figure 9: Experiment 5 - Initial State

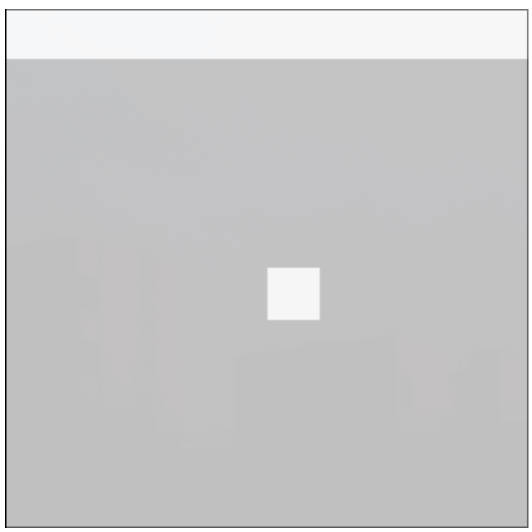

Figure 10: Experiment 5 - Final State

Experiment 6

Group A cells move in a pseudo-random manner to form segregated clusters.

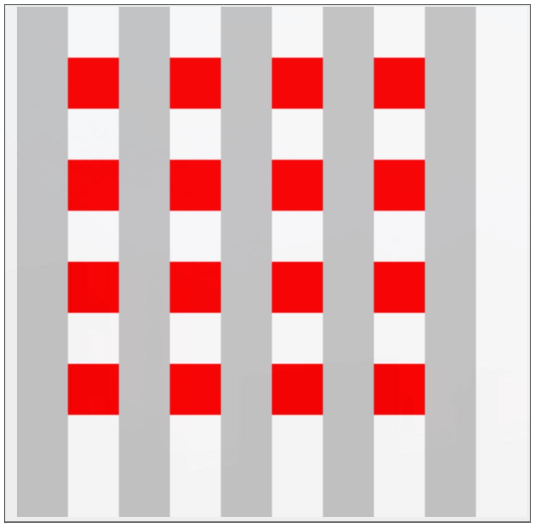

Figure 11: Experiment 6 - Initial State

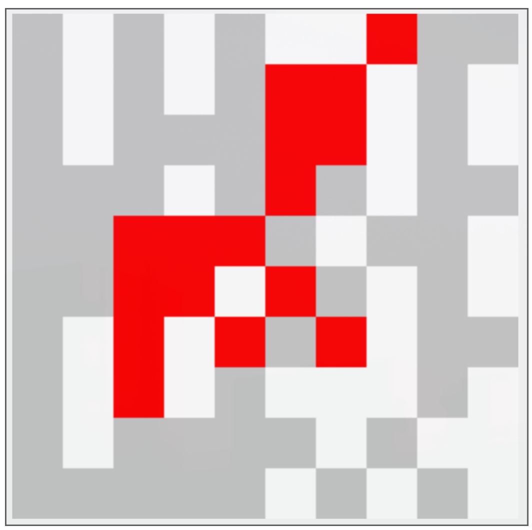

Figure 12: Experiment 6 - Final State

Conclusion

The segregation model showcases the natural segregation pattern that arises when cells attempt to be surrounded with at least 50% of similar cells. While this does not necessarily create uniform blocks, and sometimes results in simple neighborhoods with mixed cells, in most cases the cells aggregate into large clusters of similar neighbours.

Potential Improvements and Remaining Work

- Cells currently move to the first available empty cell. Making moves random would generate different patterns.
- A cell could check the neighborhood of the empty cell before moving to ensure it satisfies the 50% rule.
- Adding more dimensions to the cell state (e.g. multiple characteristics) could allow modeling more complex segregation behaviors.