An Investigation of the Effects of Population and Satisfaction Thresholds on Segregation Within A Schelling Model

Christian Piper

Robotics Department, Worcester Polytechnic Institute

RBE511 - Swarm Intelligence

Dr. Akin Tatoglu

Homework 3 Report

September 12th, 2024

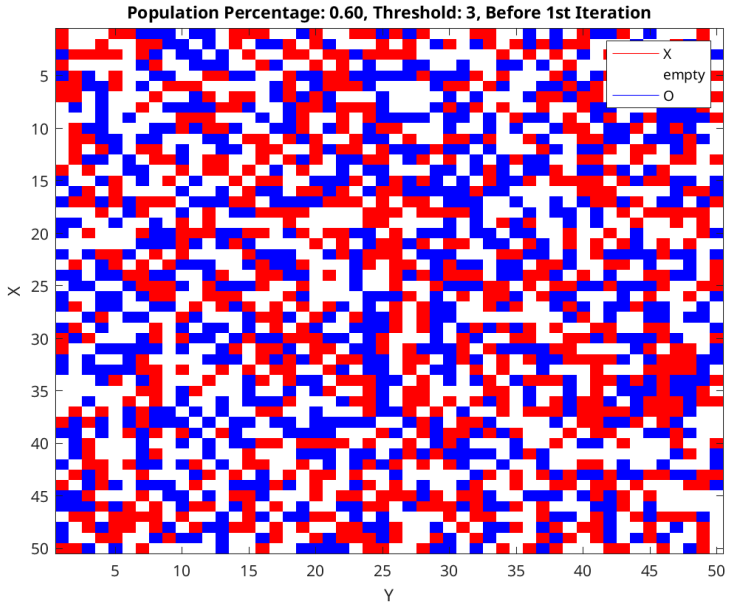
Introduction

In this report, I present the results of my observations of a Schelling model. The Schelling model is a mathematical model that simulates the behavior of agents who make decisions based on their preferences for the composition of their neighborhood. It is a simple but powerful model that has been used to study a wide range of phenomena, including segregation, opinion formation, and the evolution of social networks.

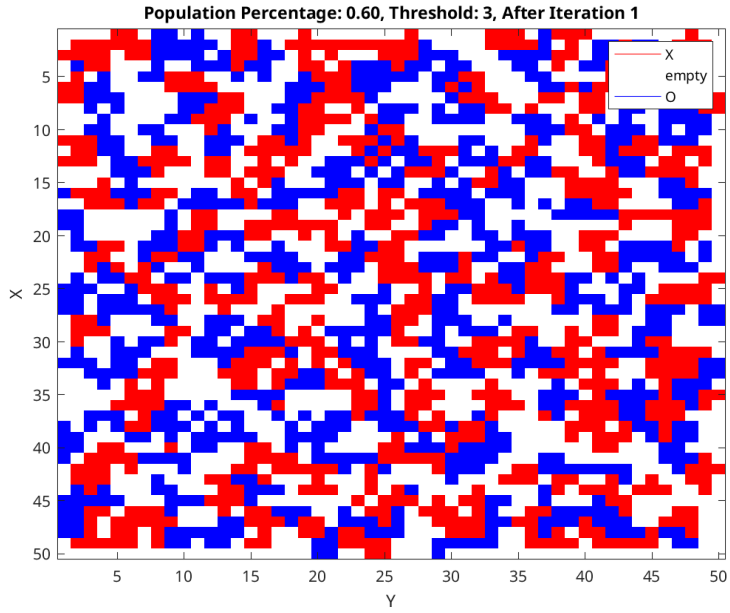
For my implementation, I wrote a Matlab script that generates a 50x50 grid. A population of 50% Xs and 50% Os is placed randomly throughout the grid at the beginning of the simulation. Agents are updated according to the cell that they occupy, left to right and top to bottom. Agents are unsatisfied when the number of similar neighbors of 8 around them is below the given threshold. Each iteration, these unsatisfied agents move to the closest cell that makes them satisfied. Closest satisfactory cells are ranked by Chebyshev distance.

Simulations were run on every combination of population percentages and satisfaction thresholds. The tested population percentages, 60% and 80%, are the ratio of agent cells to overall grid cells. For satisfaction thresholds, the values of 3, 4, and 5 were used. During the tests with a satisfaction threshold of 5, 80% of the agents of each type had thresholds of 3 and 20% had thresholds of 5. Each simulation ran for 25 iterations. Snapshots of the grid were taken before the first iteration, after the first, and every 5 iterations, producing 7 images per simulation. 4 key snapshots per simulation were selected to include in this report.

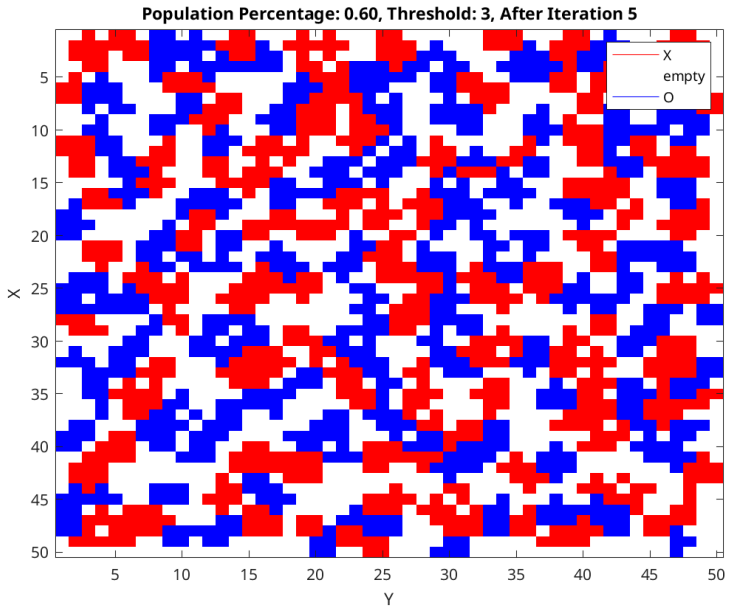
Population Percentage: 60%, Threshold: 3



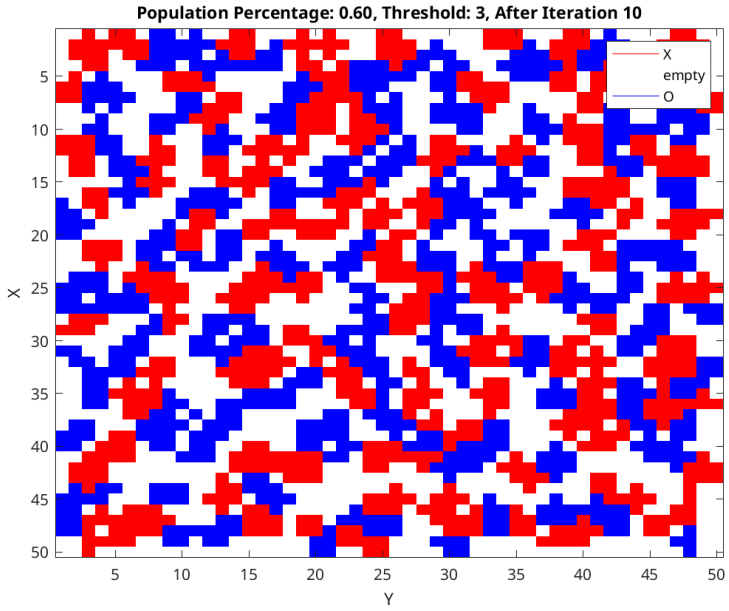
The starting grid shows a thorough mixing of agents.



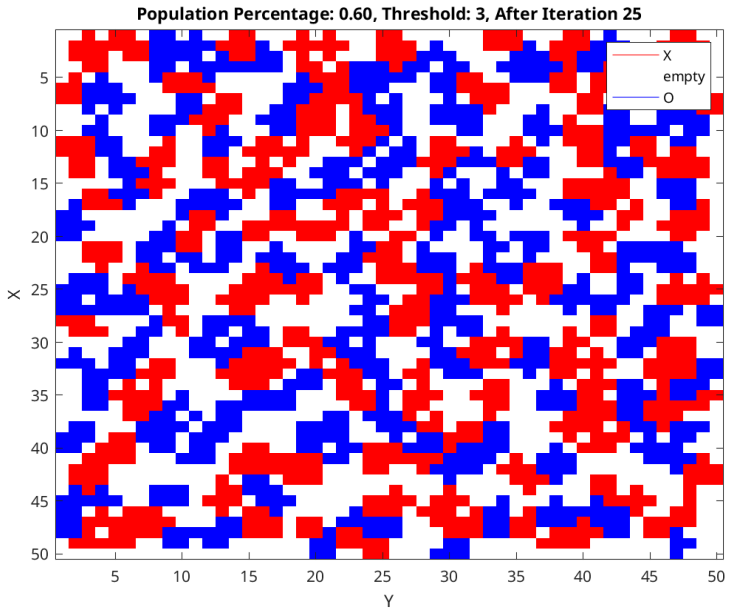
Beginning with the first simulation, there is little change in the grid after the first iteration. There is some segregation starting to form, but the populations are still mixed.



Continuing, there is no noticeable change between the grid after iteration 5 when compared to after iteration 1. The segregation has plateaued. This is likely due to the high availability of empty space and a relatively low satisfaction threshold.

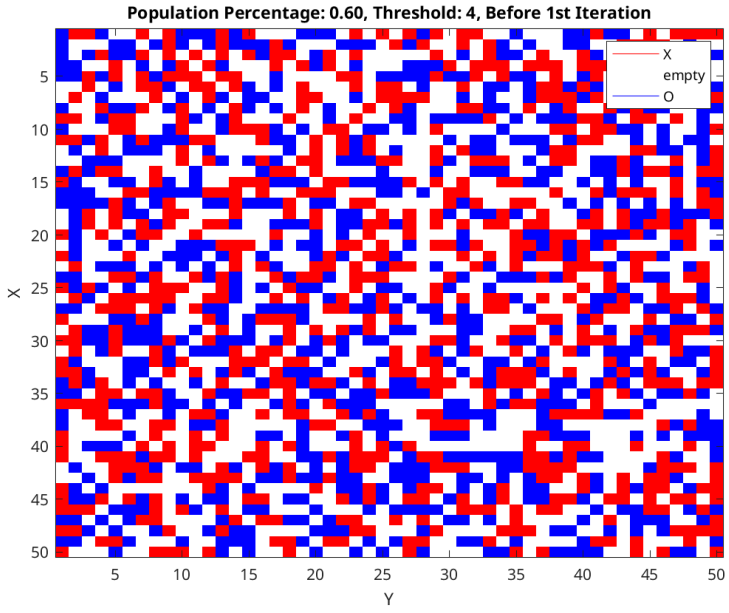


The snapshot after iteration 10 shows extremely minimal change from iteration 5 to 10. Almost all of the agents are satisfied, meaning the grid has reached a steady state.

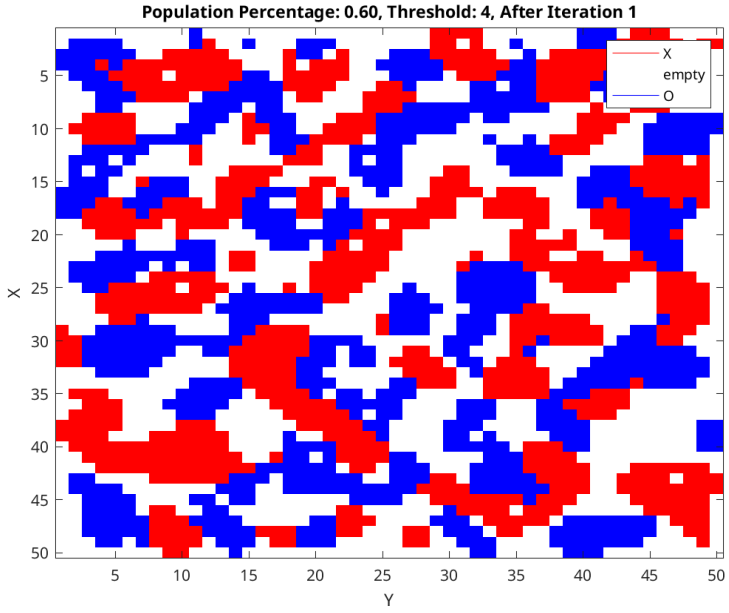


The final state of the simulation confirms the theory that segregation has reached a steady state. The grid after iteration 25 is identical to after iteration 5.

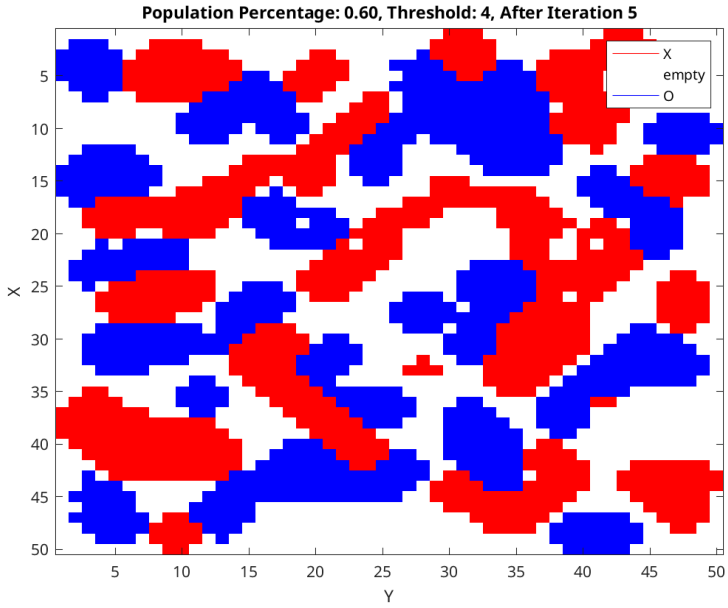
Population Percentage: 60%, Threshold: 4



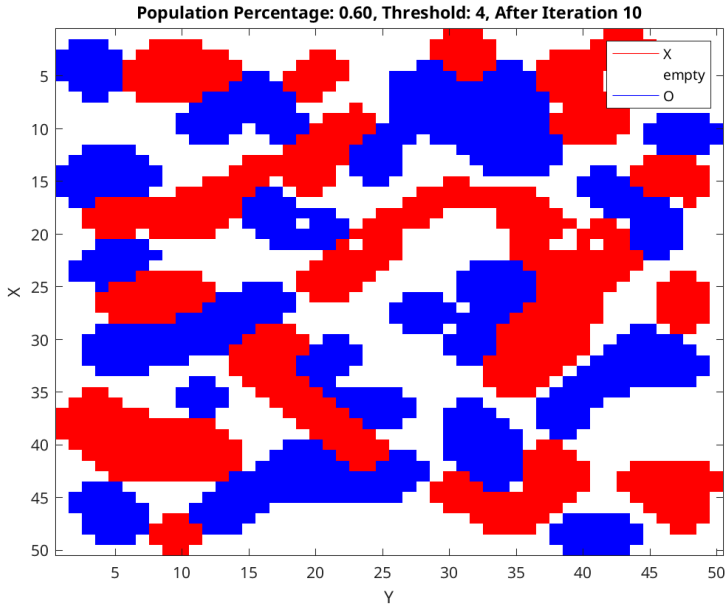
The starting grid shows a thorough mixing of agents.



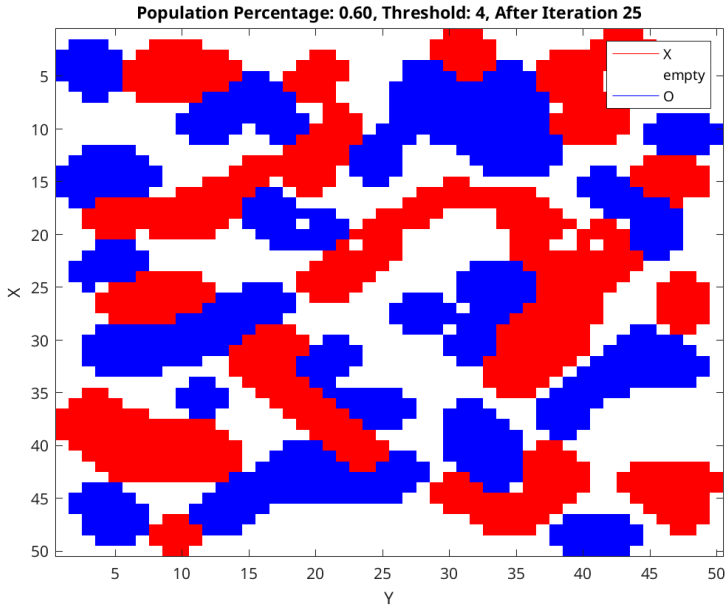
Beginning with the second simulation, there is some change in the grid after the first iteration. There is significantly more grouping than the previous simulation, likely due to the higher satisfaction threshold.



Continuing, there is a progression of segregation after iteration 5 when compared to after iteration 1. The results contrast the previous simulation, where grouping had already reached capacity. This is likely due to the relatively higher satisfaction threshold.

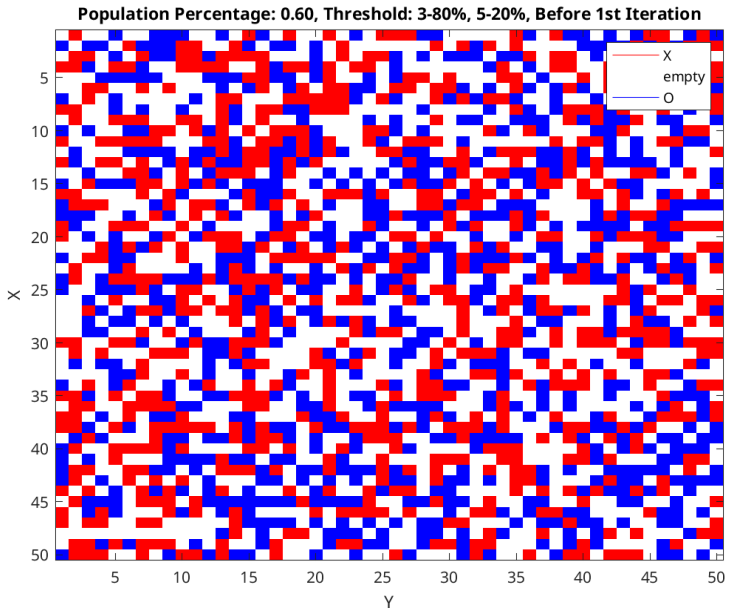


The state of the simulation after the 10th iteration shows that segregation has reached a fairly steady state. The grouping is nearly identical to the grid from after iteration 5.

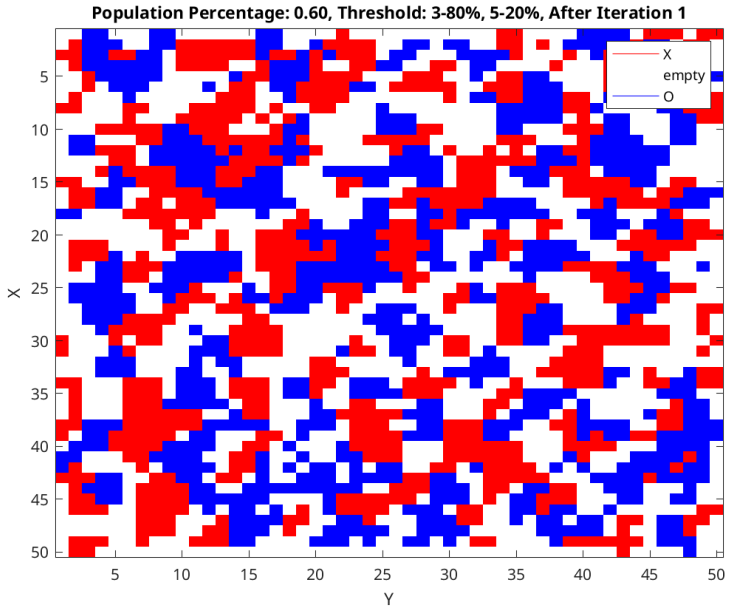


A snapshot after iteration 25 shows that segregation has plateaued. All agents are satisfied.

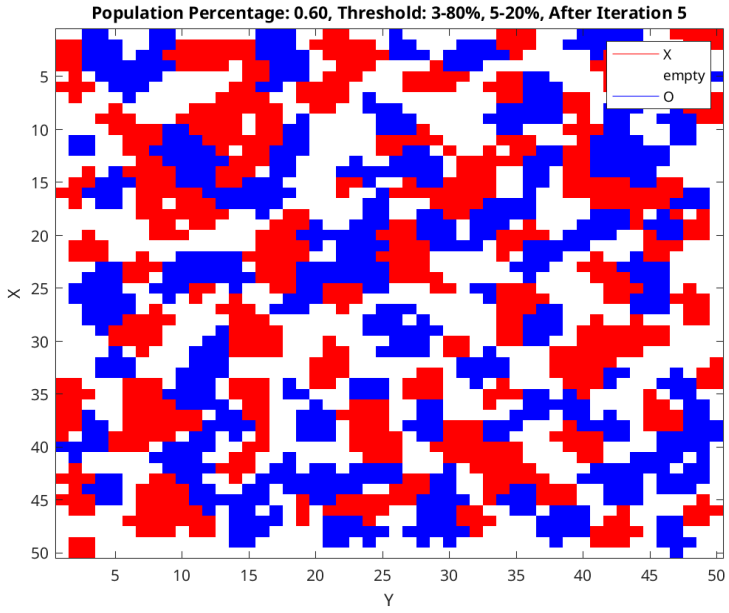
Population Percentage: 60%, Threshold: 3 - 80%, 5 - 20%



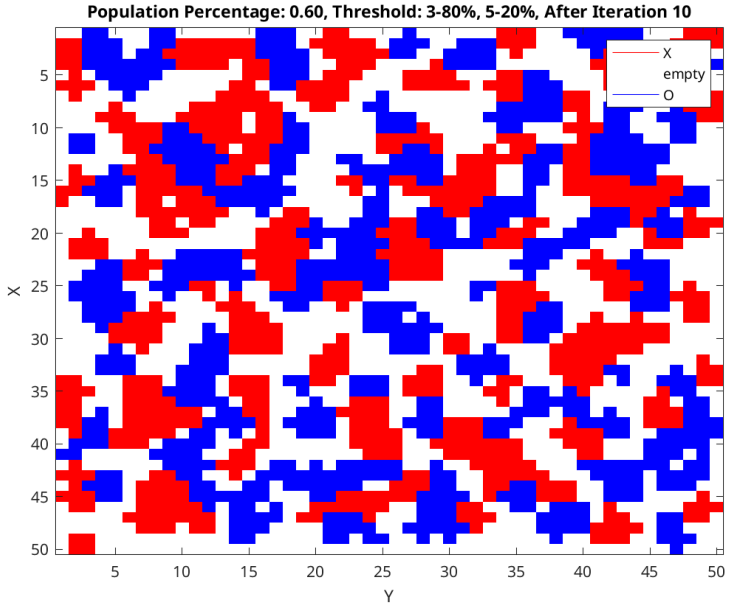
The starting grid shows a thorough mixing of agents.



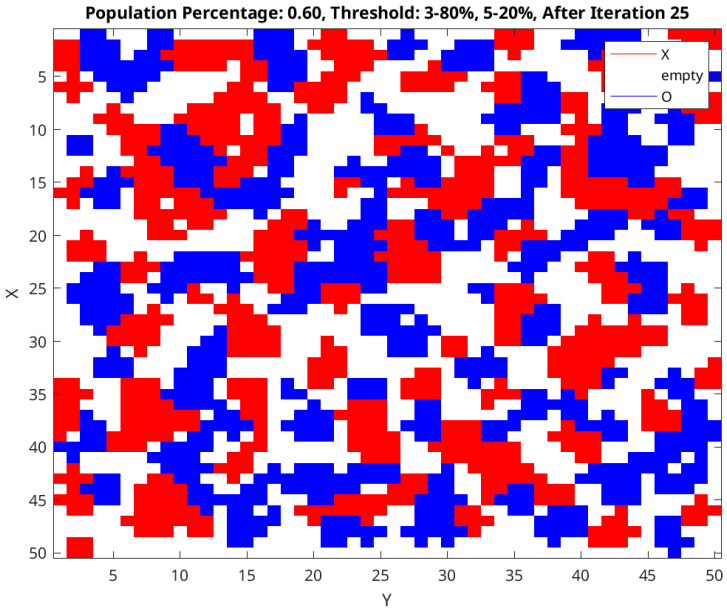
Beginning with the first simulation, there is some change in the grid after the first iteration. There is some segregation starting to form, but the populations are still mixed. The change is similar to that observed in the previous trial.



Moving on, there is a small progression of segregation after iteration 5 when compared to after iteration 1. The results contrast with the previous simulation, which showed significantly more change between iterations 1 and 5. The difference more closely matches the change between iterations 1 and 5 of the first simulation. This is likely due to the high availability of empty space and a similar satisfaction threshold. Although some of the agents are different, the majority have an identical threshold to the first simulation.

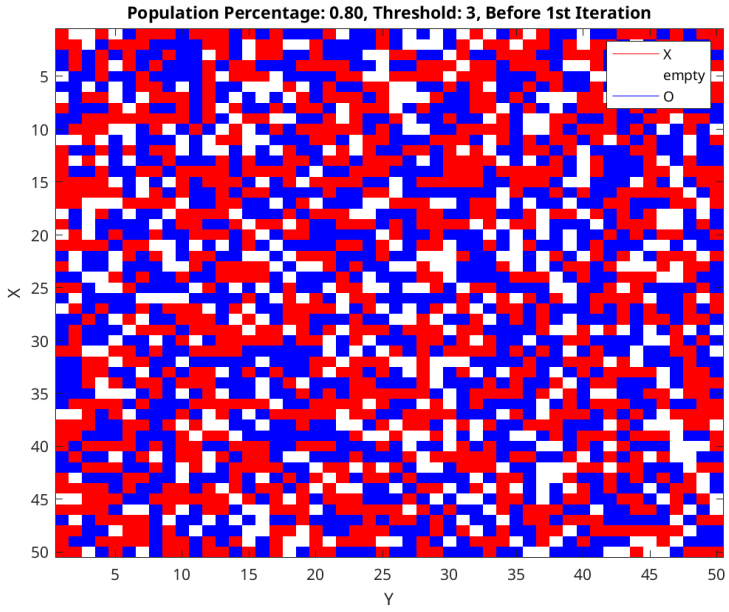


The state of the simulation after the 10th iteration shows that segregation has reached a fairly steady state. The grouping is nearly identical to the grid from after iteration 5.

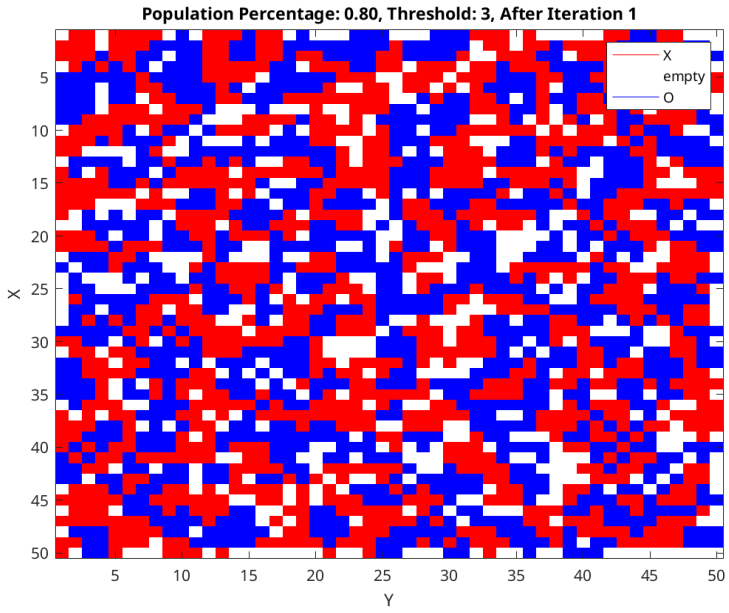


A snapshot after iteration 25 shows that segregation has plateaued. All agents are satisfied. This matches the results of the other simulations so far.

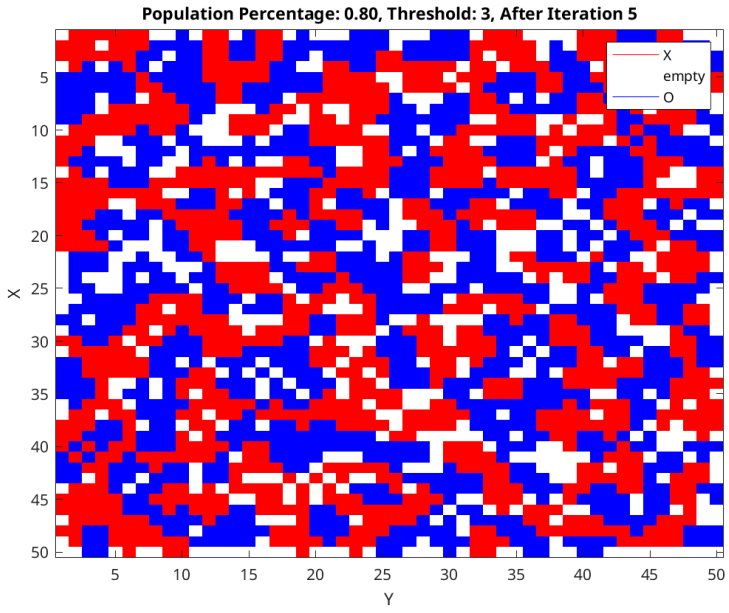
Population Percentage: 80%, Threshold: 3



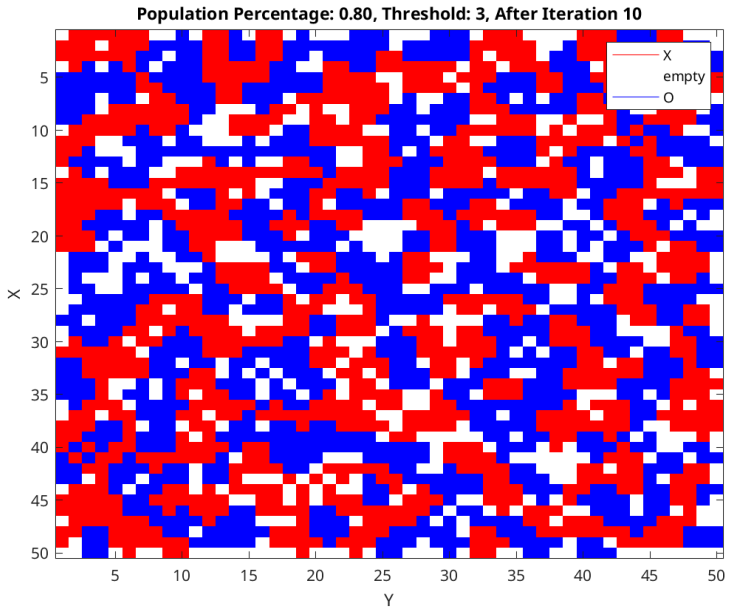
The starting grid shows a thorough mixing of agents.



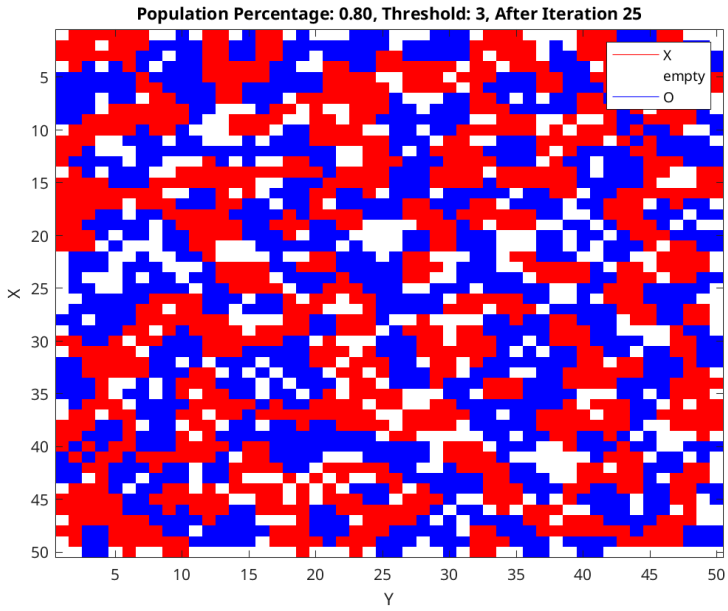
Beginning with the fourth simulation, there is some change in the grid after the first iteration. There is some segregation starting to form, but the populations are still mixed. The change is smaller than the simulation with the same threshold and 60% population. This is likely because there are less spots available to move to.



Continuing, there is only a small noticeable change between the grid after iteration 5 when compared to after iteration 1. The segregation has mostly plateaued. This is likely due to the relatively low satisfaction threshold.

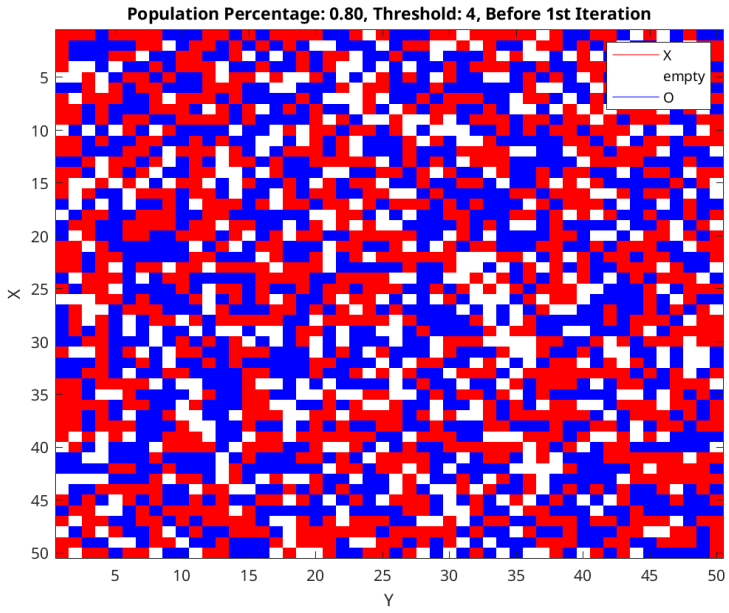


The snapshot after iteration 10 shows extremely minimal change from iteration 5 to 10. Almost all of the agents are satisfied, meaning the grid has reached a steady state.

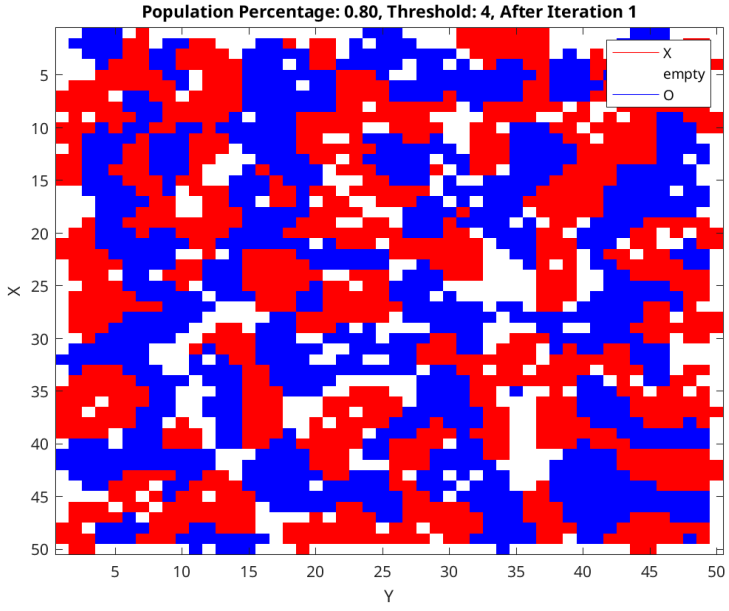


The final state of the simulation confirms the theory that segregation has reached a steady state. The grid after iteration 25 is identical to after iteration 5. This is identical to the 60% population test with the same threshold. The low threshold means that agents are easily satisfied.

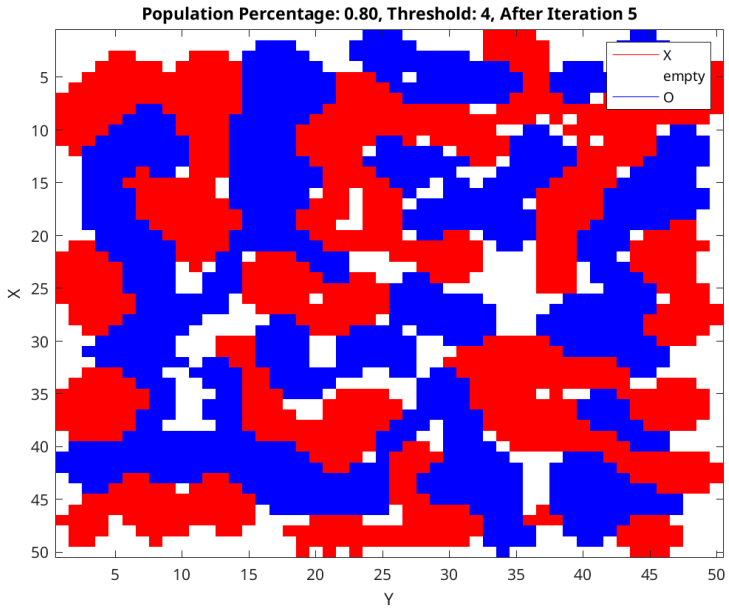
Population Percentage: 80%, Threshold: 4



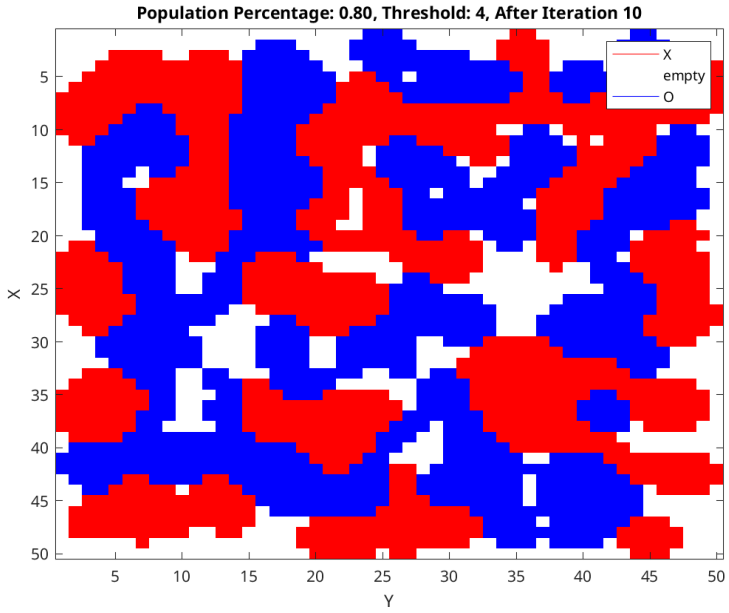
The starting grid shows a thorough mixing of agents.



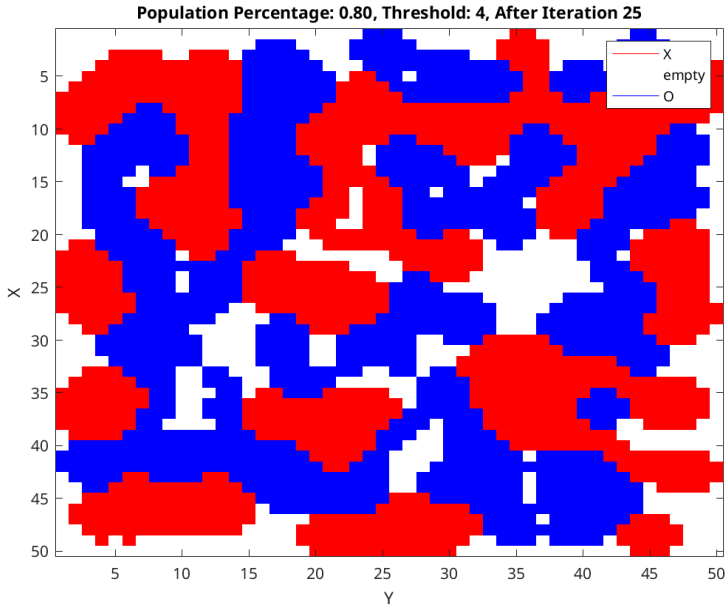
Beginning with the fifth simulation, there is significant change in the grid after the first iteration. There is more grouping than the previous simulation, likely due to the higher satisfaction threshold. This result mirrors the 60%, 4 threshold test.



Continuing, there is a large progression of segregation after iteration 5 when compared to after iteration 1. The results contrast the previous simulation, where grouping had already reached capacity. This is likely due to the relatively higher satisfaction threshold and less availability of empty spaces.

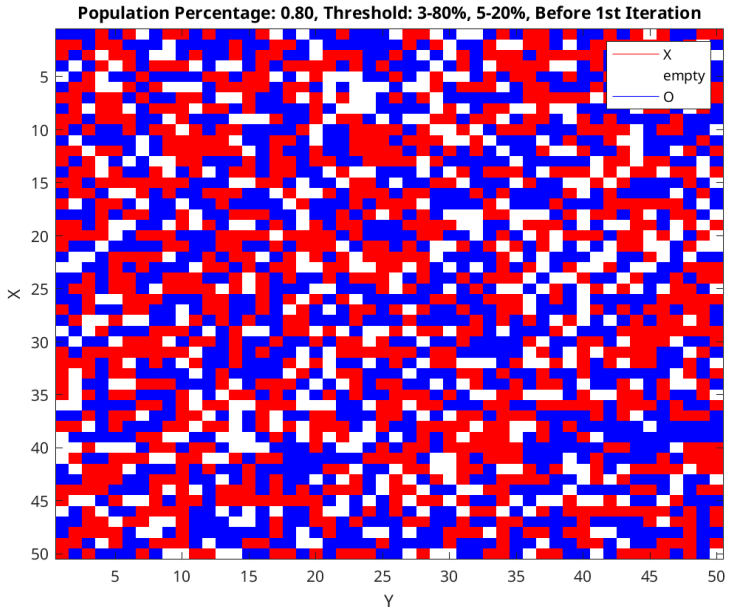


The state of the simulation after the 10th iteration shows that segregation has reached a fairly steady state. The grouping is nearly identical to the grid from after iteration 5. This result matches the 60% population test with the same threshold. It makes sense as the threshold rate is identical.

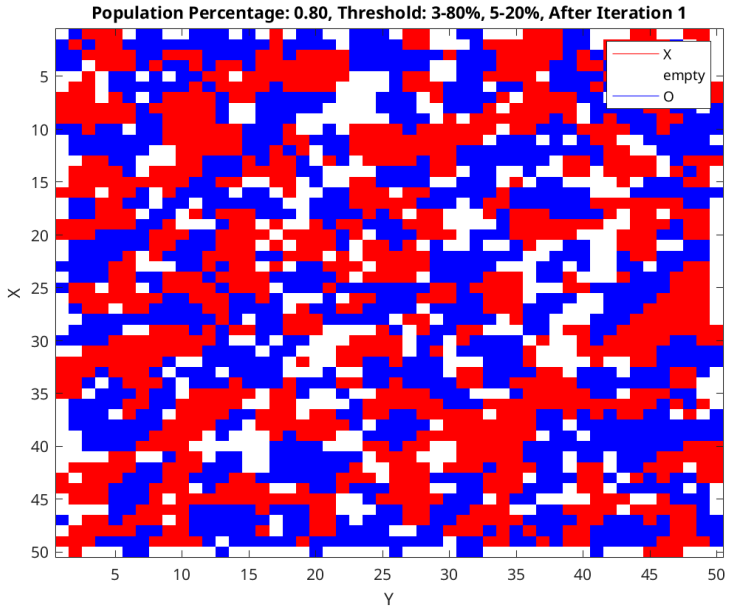


A snapshot after iteration 25 shows that segregation has plateaued. All agents are satisfied. This matches the results of the other simulations so far.

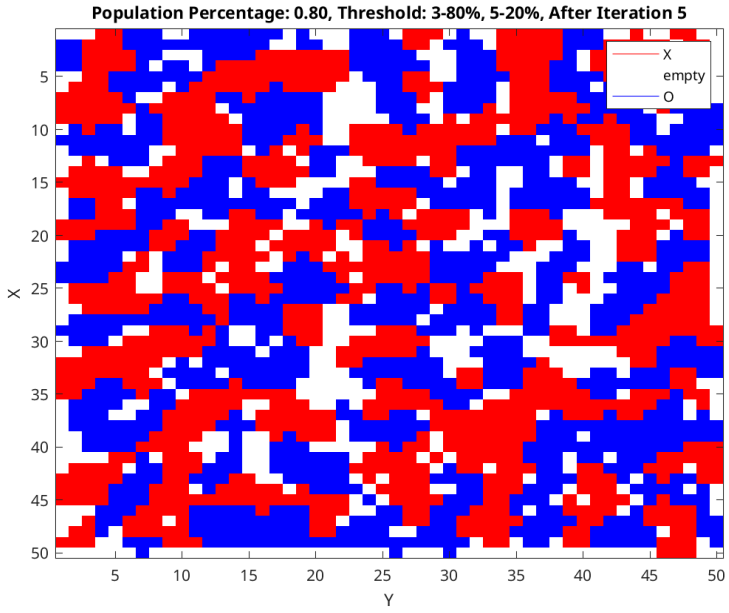
Population Percentage: 80%, Threshold: 3 - 80%, 5 - 20%



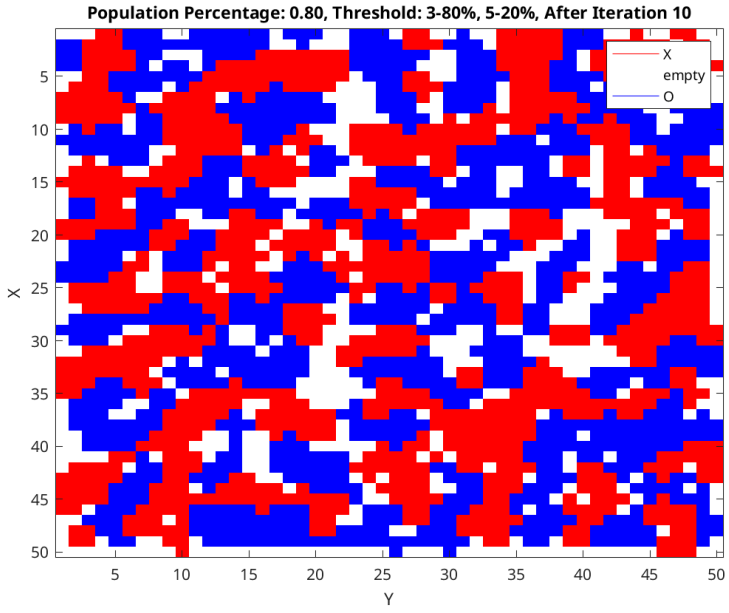
The starting grid shows a thorough mixing of agents.



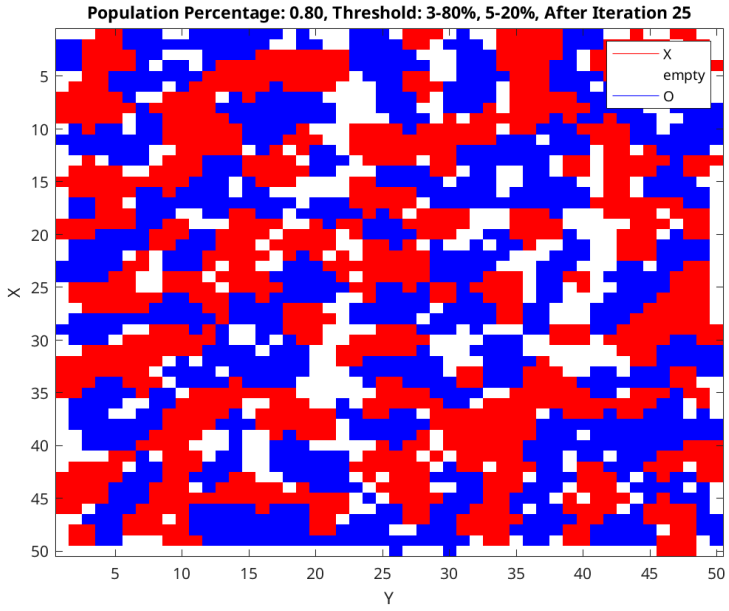
Beginning with the final simulation, there is major change in the grid after the first iteration. Segregation is starting to form, but the populations are still mixed.
The change is similar to that observed in the previous trial.



Moving on, there is a small progression of segregation after iteration 5 when compared to after iteration 1. The results contrast with the previous simulation, which showed significantly more change. The difference more closely matches the change between iterations 1 and 5 of the first simulation. This is likely due to the similar satisfaction threshold. Although some of the agents are different, the majority have an identical threshold to the first and fourth simulation.



The state of the simulation after the 10th iteration shows that segregation has reached a fairly steady state. The grouping is nearly identical to the grid from after iteration 5.



A snapshot after iteration 25 shows that segregation has plateaued. All agents are satisfied. This matches the results of the other simulations. It seems as though all of the simulations hit a point where the majority of agents are satisfied and segregation reaches an equilibrium.

Conclusion

In this paper, I presented the results of my observations of a Schelling model. I investigated the effects of varying the population percentage and satisfaction threshold on the segregation patterns that emerged.

My results showed that the population percentage and average satisfaction threshold had a significant impact on the segregation patterns. In general, higher population percentages and lower satisfaction thresholds resulted in more segregation. This is because agents with higher satisfaction thresholds were more likely to be dissatisfied with their neighborhood and move. Additionally, agents in higher population percentages had fewer empty spaces to move to, which also contributed to segregation.

These results suggest that the Schelling model can be used to study a variety of real-world phenomena, such as segregation, opinion formation, and the evolution of social networks. For example, the model could be used to study how different policies, such as affirmative action or school choice, affect segregation patterns. Additionally, the model could be used to study how different social media algorithms affect opinion formation.

Overall, my results provide new insights into the Schelling model and its implications for understanding real-world phenomena.