Computational Modelling – Project

Racial Segregation Simulation with Agent-Based Schelling's Model

INTRODUCTION

The Schelling model of segregation is an agent-based model, which illustrates a world with a particular system's behaviour and individual tendencies to form segregation. The basic Schelling model contains a two-dimensional gridded world, where two kinds of agents (red and blue) occupy cells with a certain ratio and some allocated empty cells. At any different time step, an agent can be happy or unhappy, 'tolerant' or 'intolerant', depending on the neighbourhood's ratio of similar agents. The unhappy or 'intolerant' agent then moves to a random selected empty cell and the new environment's assessment is repeated.

Despite the Covid-19 pandemic spreading around the world, racial segregation is still prevalent in society. In 2011, Monash City Science produced an illustration of ethnicity division in Melbourne.

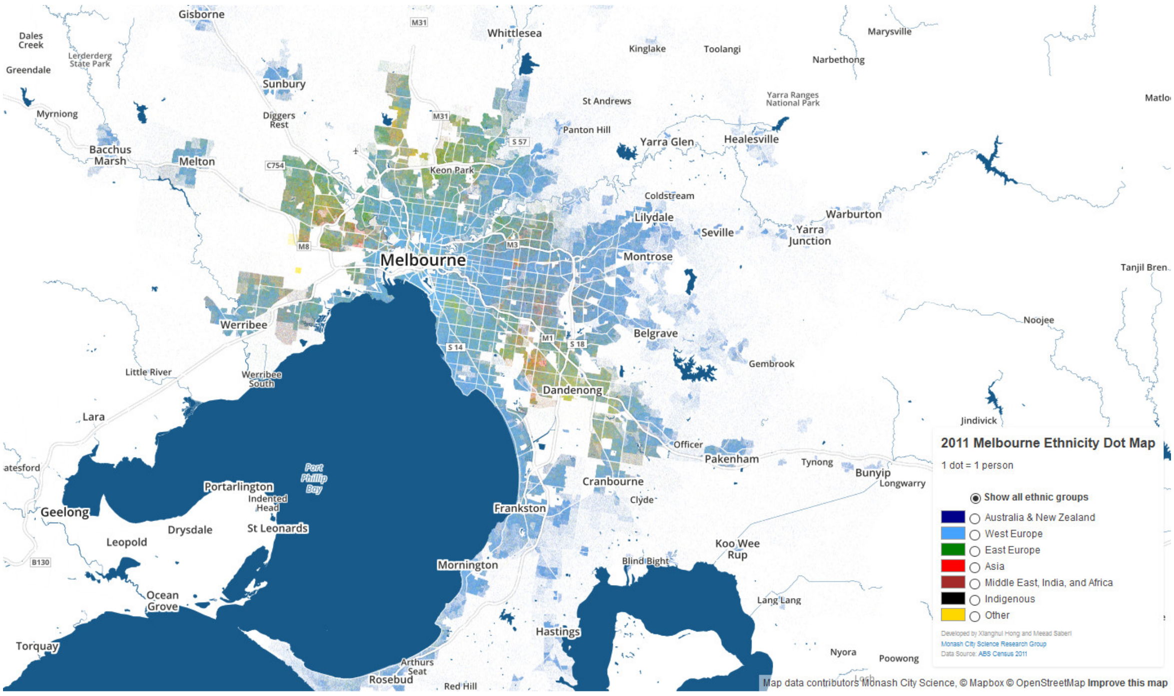

Figure 1. 2011 Melbourne Ethnicity Dot Map (Monash City Science 2011)

In addition, ethnic segregation is still visible even in a city that has been considered the most multicultural city in the world (Oliver 2018).

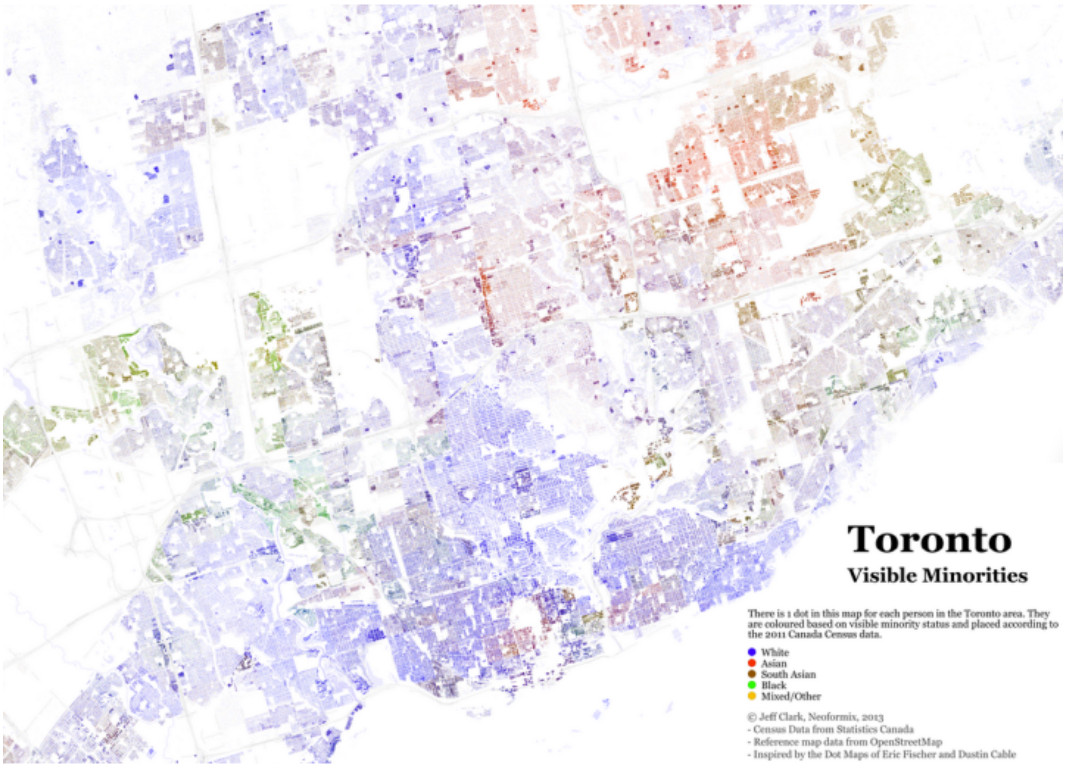

Figure 2. Toronto Visible Minorities (Clark 2013)

The implementation of the Schelling model creates a visual illustration that represents this racial segregation. Since ethnicities in the real world are more diverse than the number of agents in the Schelling model, the model design used in this project increases the number of agents from two to three.

MODEL IMPLEMENTATION

Different ethnicities with cultural diversity represent each individual's identity and shape the community in society. In a world where there is no empty space and there are three different ethnicities (agents), they form three happy-living community segregated patches. This is using a basic method to fill in a gridded two-dimensional world, given a total of 50 rows in a grid. The division among the three agents is equal, representing happy-living ethnicities and communities. This is illustrated below:

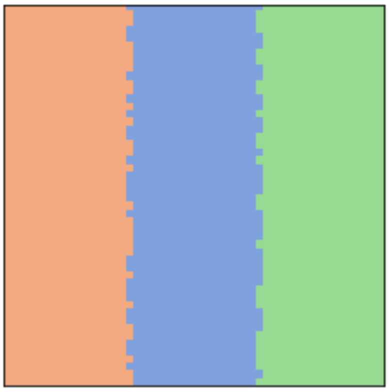

Figure 3. Three segregated patches with no empty cell

Nevertheless, a happy-living society simulated above is almost impossible to achieve in the real world. Below is an illustration of a world with a 0.3 threshold on a tolerant state ('happy' state) and with three kinds of agents living with the same ratio numbers:

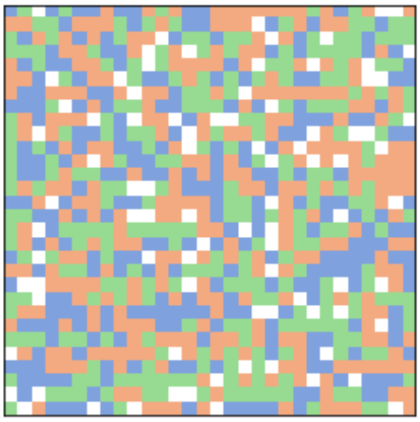

Figure 4. Three agents with the same ratio numbers

With three kinds of agents trying to find their happy state, it takes a lot more number of time steps to achieve this. A simulation run for a gridded world of 100 rows, with a 0.3 threshold level of being happy or tolerant has shown the state of the three agents with the same ratio numbers (3:3:3 and 10% of empty cells) in time steps 0, 50 and 2000:

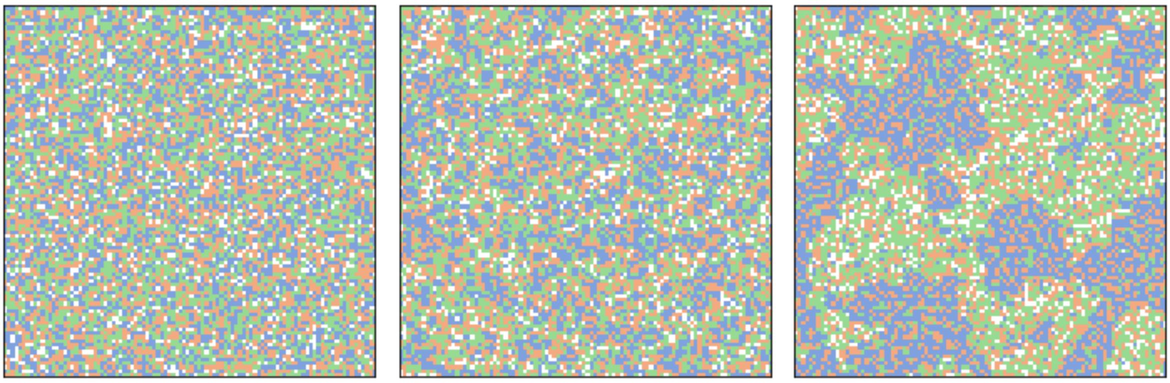

Figure 5. Tolerant agents after 2000 time steps

It can be seen above that it takes 2000 time steps to have the segregation become quite visible. In comparison, the same gridded world of 100 rows, with 0.7 threshold level has required fewer number of time steps to reach a tolerant or 'happy' state for two agents with the same ratio numbers against 10% empty cells. This has been achieved in time steps 0, 2 and 50:

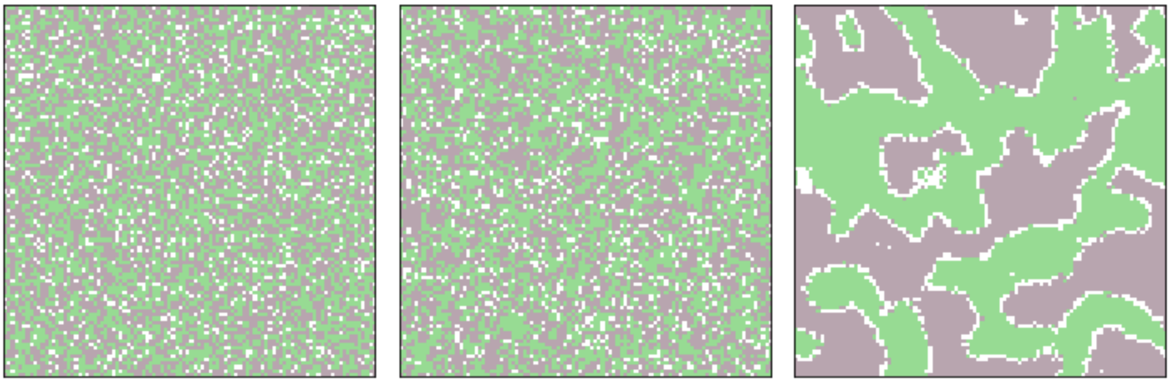

Figure 6. Tolerant agents after 50 time steps

This comparison has shown that the more diverse ethnicities in a community require a lower threshold level on tolerance towards other individuals of different races. More time steps are also needed to be taken to create racial segregation in a community, where the different kinds of agents can live in their cells in a 'happy' state.

Below is the simulation of the interaction between segregation and time steps for a world with three kinds of agents:

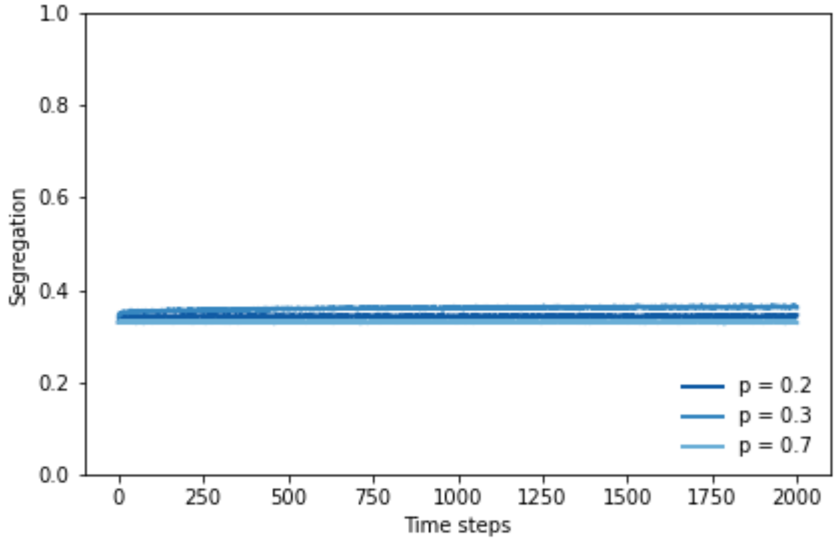

Figure 7. Three agents with 2000 time steps

It is more difficult to see the difference between the three given threshold level, given three kinds of agents living in a two-dimensional gridded world. Compared to the two agents of Schelling's model below, it can be seen that at p=0.7, the full segregation of two agents can almost be fully achieved:

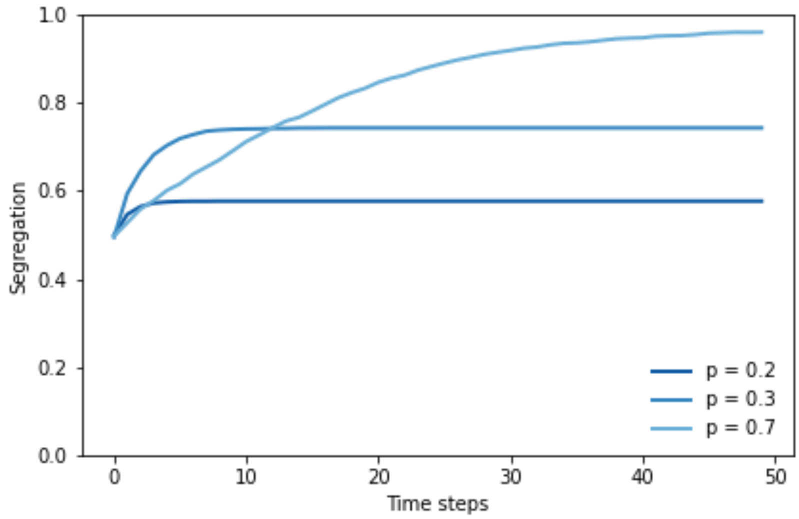

Figure 8. Two agents with 50 time steps

Model Implementation in a Less-Populated Area

The suburban areas contain less population, which is represented by a model with more empty cells and less proportion of agents in a gridded world of 50 rows with a 60% proportion of empty cells. This illustration is as follows:

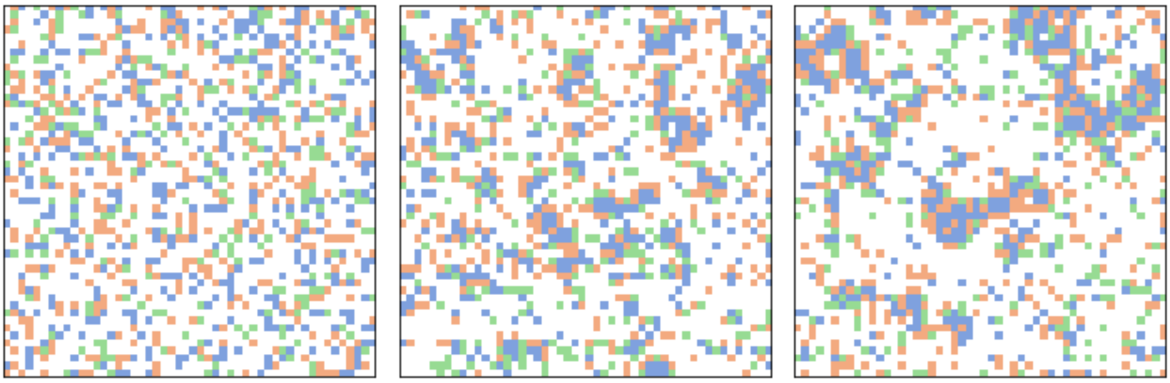

Figure 9. A world with more empty cells

The simulation is at time steps 0, 50 and 100. It can be seen from the above simulation that as there are more empty cells available around the world, intolerant ('unhappy') agents have more flexible options to move to a new cell. Therefore, the number of time steps taken by the agents to find happiness by moving to a new cell is less than when the world is more crowded. It can be seen from the diagram below that the lower the threshold level, the higher the segregation level a less-populated world can achieve. A threshold level of 0.2 can achieve a higher level of segregation compared to the higher threshold levels of 0.3 and 0.7. This relation between the threshold level, segregation and number of time steps is illustrated below:

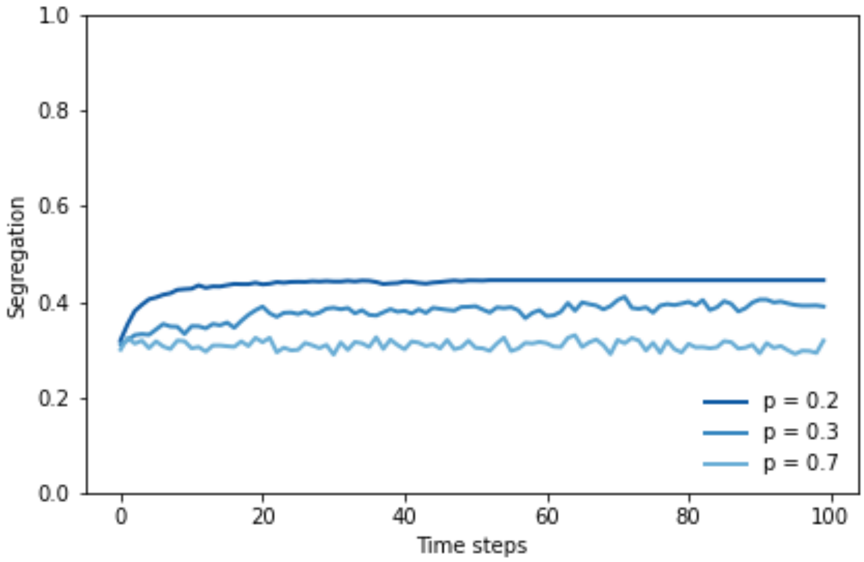

Figure 10. The lower threshold level for a higher segregation level

On the other hand, in a populated world, where there is 99% agents occupancy rate and a 1% proportion of empty cells, there is a low number of available cells for the 'unhappy' agents to move and find happiness in the new environment and form segregation. This simulation is shown below with a gridded world of 100 rows, 1% empty cells, executed in three different time steps of 0, 50 and 100:

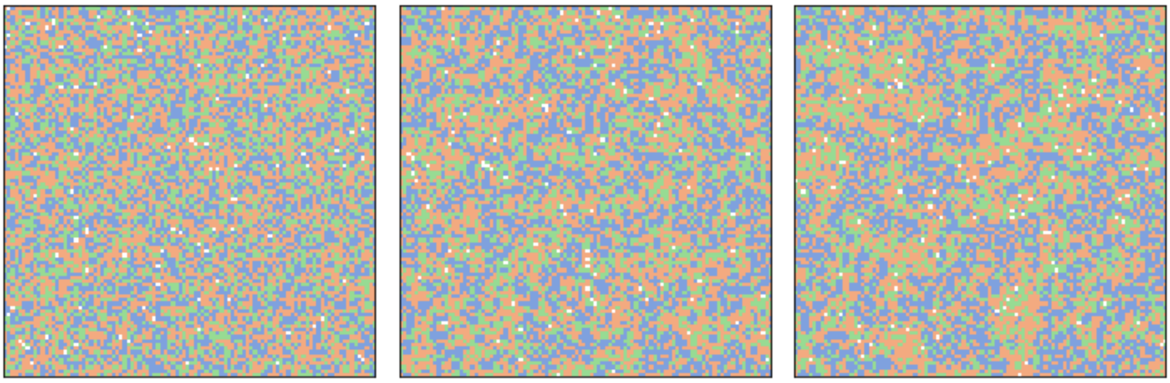

Figure 11. A well-populated world with 1% empty cells

The above simulation indicates a few numbers of available spaces for the agents to find their 'happy' state in a new environment and form segregation. Since there are only a few available spaces, some level of segregation can be reached after a certain level of time steps, however, the 'unhappy' agents keep moving as they can hardly reach happiness in a stable state.

A SIMULATION USING REAL-WORLD DATA BY THE AUSTRALIAN BUREAU OF STATISTICS

Based on the census data of population and housing conducted by the Australian Bureau of Statistics, the population of Western Australia consists of Europeans of any race 61%, Asians of any race 15%, and Africans of any race 3.9%. The real data from the Australian Bureau of Statistics is processed to become a csv file, with a summed number of ethnicities based on the continents. The number estimation may be inaccurate, however, is still used to support a simulation for the majority number of ethnicity, represented by a 'green' color agent in a two-dimensional gridded world in this project, as follows:

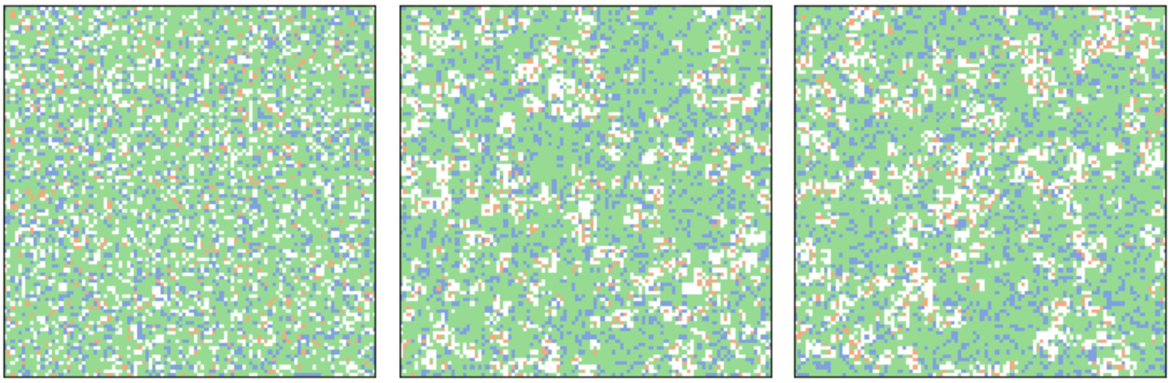

Figure 12. Simulation for an agent with majority number swiftly forming segregation

It can be seen after 50 and 100 time steps, all agents form segregation and try to find their happiness. The majority of the ethnicity from the Europeans illustrates that the agents can easily form segregation and find their new cell with ‘happy’ state, as the other agents are still moving around.

CONCLUSIONS

The simulations in this project illustrate how individuals’ preferences can affect their level of happiness and decision to move to a new location with the same culture or ethnicity, hence creating a more segregated world. Schelling’s agent-based model helps to demonstrate a higher level of difficulty for a world with more diverse agents to become segregated. Furthermore, a less-populated world, which contained more empty cells, allows unhappy agents to be more flexible and faster in finding happiness in a new empty location. In contrast, a well-populated world gives little space for the unhappy agents to explore and move, hence creating a world with a more unstable state as the agents tend to keep moving. The ethnicity which has a majority number of the population in a gridded world simulates how fast and easily the agents find a new cell with a ‘happy’ state and form segregation.

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