Simulating Social Systems with Matlab - Residential Segregation in Zurich

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Simulation of Residential Segregation using an Agent Based Model in Matlab blabla

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Abstract In this report the segregational behavior of Zurich's population was studied using a more dimensional model similar to the one Schelling came up with in the sixties. An agent based simulation model was implemented in Matlab and information about origin, age and family state was provided by the statistical department of the city of Zurich. In the model, each agent was given a random site in one of the twelve districts of Zurich and then according to her/his own characteristics she/he had to chose whether she/he wanted to stay or leave the place. Tolerances towards the four Von-Neumann neighbors in the two dimensional grid for all the three characteristics and towards the average of the district of the characteristics were changed in the simulations. An other parameter was the "threshold happiness" an agent must have at a certain place to be willing to stay there with the given situation.
The results show ...

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Contents

1 Individual Contribution

Table 1 shows the individual contributions to the project of the two group members.

Table 1: Contribution of the group members

Brechbuehl Sonia	Buechi Jonathan
Data research	Data research
	Implementation Code
Writing report	
Analysis and Evaluation	Analysis and Evaluation
Presentation	Presentation

2 Introduction and Motivation

The segregation of people in living areas of cities is a well known phenomena which was investigated strongly in the past. Because we are living in Zurich we would like to find out more about the social situation here. Zurich is a multi cultural city, many people from different origins and social backgrounds are living here. A combination of circumstances and characteristics of people makes their segregational behavior a complex problem. In order to investigate this interactions, in this paper a general model based on the data of Zurich is implemented and tries to simulate their segregational behavior due to differences in age, family state and origin.

2.1 Theory

2.1.1 Residential Segregation

Residential segregation can be a result of different origins. Firstly there is the non-tolerance of people towards others of different religion, origin, color, sex, age, income, language etc. It is clear that this segregation aspect is due to individual choices that discriminate. A model which describes this segregational aspect was brought up by Schelling [1]. Segregation can also be economically determined, e.g. by housing prices

in certain areas, such that certain people can not afford to life in expensive areas which are mostly also more attractive i.e. "better". Like this one can often observe ghetto formation in bigger cities [2].
This paper only treats the segregation that results from forms of discrimination. The people in the model have different origins, age and family state and a certain tolerance to accept people which are different from themselves in their direct neighborhood. It can be understood as an extension of the work by Schelling [1] to more than one dimension and more than one tolerance parameter.

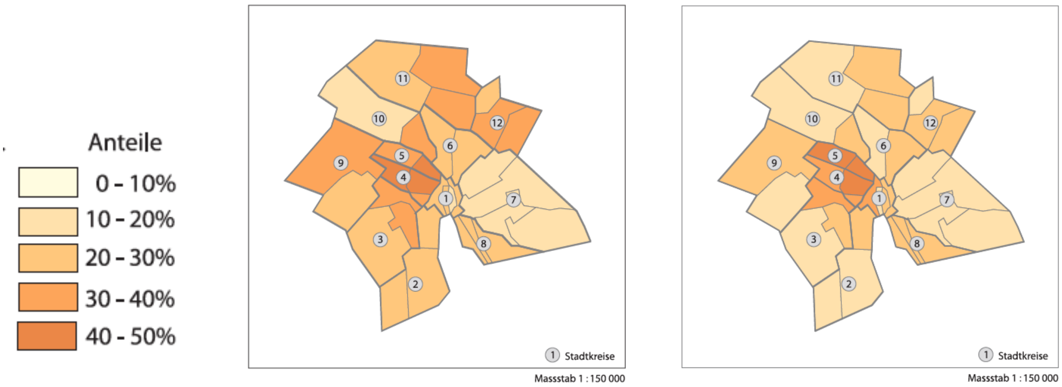
2.1.2 Agent Based Modeling

Residential segregation is a dynamic and interactive process. Therefore one has to make use of a model which considers each of the actors in it as an autonomous individual, who makes decisions and then moves accordingly in the next time step. Agent based Modeling (ABM) was firstly used in the late 1940s and is a way to simulate autonomous agents, their actions and interactions with each other and the environment in a system and therefore tries to see the results of this in macro-level phenomena [2]. In this way, ABM is a good choice to simulate dynamically the discrimination based segregation in an area due to choices of the agents [3].

2.1.3 Segregation in the city of Zurich

Using the results of studies done by the statistical department of the government of the city of Zurich [4] and [5], one can easily see that the actual situation in Zurich is quite much segregated.
In figure 1 part b) one can see as an example the foreign resident population in the different districts of Zurich in year 2000. There are districts with very little foreign population like the districts number 7 or 10 and in others like 4 live up to 50 per cent foreigners. Looking at statistics about family situation and age distribution, there is also a segregation visible. Furthermore, comparing the numbers from year 2000 to earlier statistics one can observe trends and movement among the inhabitants. In figure 1 the foreign resident population in year 1990 is shown in image c).

An even bigger difference one can see in the data on the income, wealth and social state of the inhabitants. This aspect, however, is not treated in this work.



(a) Legend (b) year 2000 (c) year 1990

Figure 1: Foreign resident population in the twelve districts of Zurich [5]

2.2 Research Questions

One of the main goals of this project is to find out whether there can be seen different segregational behaviors due to the choice of the tolerance parameter of the agents. In the model there will be six tolerances, three for the Von-Neumann neighbors, one for each criterium, and three for the differences from the agents characteristic and the respective average of all agents in the district. Can segregation be seen in the same extent if one looks only on the district average and not considers the Von-Neumann neighbors (this latter case is what Schelling was been doing in [1] for one dimension).
Furthermore, it was investigated whether a higher "overall happiness" can be reached when a certain amount of people leave their places in each step independent from their current happiness with their neighborhood, i.e. if people just move away sometimes.

3 Methods

3.1 The Data

The simulations are run with data provided from the statistical department of the city of Zurich. The data is given as can be seen in table 2. The first column represents the statistical zone, the second column the family state, the third the origin, the fourth the age and the last column the number of persons form whom these criteria are true.

Overall, a set of $333,105$ agents was used.

Table 2: Example of data used in the simulation

Statistical Zone	Family state	Origin	Age	Number of people
11104	Einzelperson	SchweizerInnen	45.45695	1661

The age (column 4) is always averaged over the number of people for which the other three criteria (stat. zone, family state and origin) are true.
Unfortunately, it was not possible to get more detailed data on the age nor data on the income and wealth of the people.

3.2 Model and Implementation

Comment: For simplicity only male pronouns are used for the agents in the following description.
The model used was an agent based model with the agents representing each an inhabitant of the city of Zurich. As explained in the previous section, they have three characteristics: An origin, i.e. Swiss or foreign, a family state and an age. This was implemented by using a structural array for each agent. A vector with all the $333,105$ structural arrays was created.
The city of Zurich can be imagined as a vector of length $333,105$ divided into twelve parts, each with length according to the relative size of districts one to twelve. To avoid places which are not taken by an agent the respective fraction of $333,105$ was always rounded down. This implicates that six agents were not participating in the events of one time step. However, since these were always randomly chosen it did not affect the results. Due to reasons explained in the previous section, the sites did not have any characteristics themselves. Furthermore, a vector with six entries was introduced, each defining the importance or weight of a given criteria for the Von-Neumann neighbors and for the district average. This can be interpreted as the tolerance of the agents (all have the same) towards the criteria. To be able to compare the results for different tolerances this vector was normalized to six (like it was if all entries were one). Furthermore, a "happiness-threshold value" (HTV) was introduced, which defined the

threshold where the agents would stay or leave a given site. This value was chosen for the different simulations between zero and six, zero meaning the agents do not care about anything in their neighborhood and six meaning they are not to be pleased by any than the absolute perfect situation.

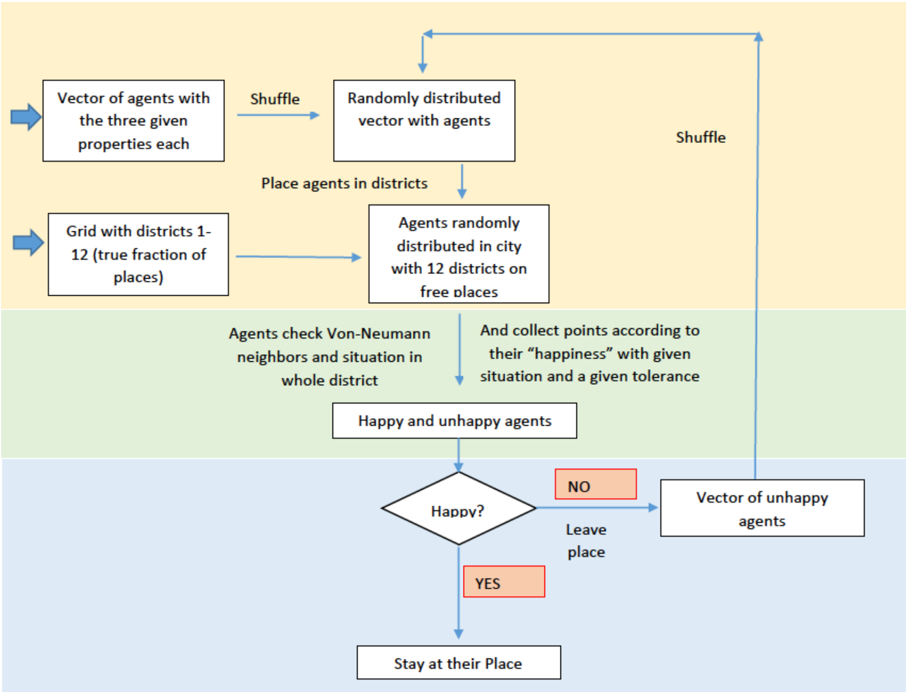


Figure 2: Schematic overview over the model

With this randomization of the agents and the known lengths of the district this can be understood as if all agents were thrown randomly on the sites of the city. This is illustrated in the yellow part of figure 2. The agents only see within their district and can not look across the borders, i.e. periodic boundary conditions for each district were used.

The percentage of Swiss and families and the average age of each district were calculated. In the blue part of figure 2 it is illustrated that each agent checked its four nearest neighbors and the averages of the respective district he was currently in. For each of the six criteria the agent collected a number between zero and one, zero meaning he was the only one of his kind (origin and family state) or his age was very different from the neighborhood, i.e. he was very unhappy with the situation for a given criteria, and one means he was perfectly fitting in. These numbers were then weighted with the accord-

ing tolerance and a "current-state-happiness value" (CSHV) was generated as the sum of all the weighted numbers. Due to all the normalizations done, this number was in the interval $[0,6]$. Comparing each agents CSHV to the HTV defined previously, each agent could decide whether he wanted to stay where he was ($CSHV > HTV = happy = stay$) or leave the site.
In the blue part of 2 it can be seen that the agents which were happy stayed at their location in the city i.e. their position in the vector, while all unhappy agents were shuffled between them, means given other locations in the city (all at the same time) and then checked again.
All codes for the different steps as well as the frame code which runs the simulation on several cores and codes for the evaluation are added in the appendix.

4 Results

5 Discussion

5.1 Conclusions and Outlook

References

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