



Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zurich

# Lecture with Computer Exercises: Modelling and Simulating Social Systems with MATLAB

Project Report

**Insert Title Here**  
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Name 1 & Name 2

Zurich  
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## **Agreement for free-download**

We hereby agree to make our source code for this project freely available for download from the web pages of the SOMS chair. Furthermore, we assure that all source code is written by ourselves and is not violating any copyright restrictions.

Name 1

Name 2

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## 1 Abstract

## 2 Individual contributions

## 3 Introduction and Motivations

The city of Zurich planing to change one specific part of the sihlstrasse in a pedestrian area. The idea is to make this area more comfortable for the visitors of the city center and it should be also an upgrade for the restaurants and shops around this area.



Figure 1: right: situation plan which shows the change of the tracks. left: illustration of the pedestrian area at sihlstrasse.

The changet will have a big impact for the traffic because there will be one track less than before. Sihlstrasse (from west to east) and Uraniastrasse (from east to west) is one of the most travelled road in the city center. It is the only alternative road to the highway (Westumfarung). If they decide to built a pedestrian area in the sihlstrasse they will lose one track from west to east. We know want to analyse the impact to the traffic jam and the impact on the neighbourhood streets.

## 4 Fundamental Questions

With our simulation, we want to answered the following questions:

1. Are the streets still large enough to manage the traffic jam peaks on working days?

2. What is the impact on the neighbourhood streets?
3. Which area or signal light is the bottleneck?

## 5 Description of the Model

### 5.1 Nagel-Schreckenberg-model

Our model is based on the prototype of cellular automata model which is called *Nagel-Schreckenberg-model*. It was developed by Kai Nagel and Michael Schreckenberg in 1992. The basic idea was to split the streets in cells, which contain only one car. Therefore we can identify on cell with the typical required space for one car in a traffic jam. Generally this length is around 7.5 m, which correspond approximately the length of the car and the average distance to the car in front in a traffic jam. Figure (2) shows a typical *Nagel-Schreckenberg-model* set-up, one cell (approx. 7.5 m)

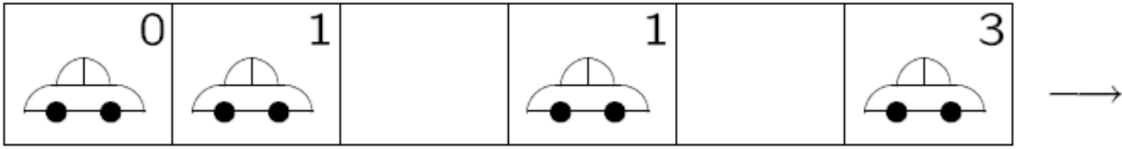


Figure 2: this figure illustrate the typical *Nagel-Schreckenberg-model* configuration: one cell (approx. 7.5 m) which can include exactly one car.

which include one car. The number in the upper right corner of the cell (which include a car) representing the actual velocity  $v_n$  of the car  $n$ . The velocity is a discrete value and we assume that the car  $n$  can have the velocities  $v_n = 0, 1, \dots, v_{\max}$ . Every car has the same  $v_{\max}$  which has the same effect like a speed limit.

With this properties one have a good description of the state of the street at time  $t$ . The next step is to define the development in time. So we have to define the state of the street at the time  $t + 1$ . To simulate this time step in the *Nagel-Schreckenberg-model* we have to define for steps, which we have to apply for each car  $n$ :

#### 1. Acceleration

If  $v_n < v_{\max}$  at time  $t$ , the car  $n$  will accelerate its velocity about one unit:

$$v_n \rightarrow v'_n = \min(v_n + 1, v_{\max}) \quad (1)$$

$v'_n$  represents the new velocity at time  $t + 1$ .

## 2. Slow down

We define  $d_n$  as the number of empty cells in front of the car  $n$  until to the next car  $n + 1$ . So if  $d_n$  is smaller than  $v'_n$ , the car  $n$  has to slow down to the velocity  $d_n$ :

$$v'_n \rightarrow v''_n = \min(v'_n, d_n) \quad (2)$$

## 3. Hang behind

If  $v''_n > 0$ , the velocity of car  $n$  will be randomly with the probability  $p$  reduced about one unit:

$$v''_n \rightarrow v'''_n = \begin{cases} \max(v''_n - 1, 0) & \text{with probability } p \\ v''_n & \text{with probability } 1 - p \end{cases} \quad (3)$$

## 4. Drive

The car  $n$  drives with the new velocity  $v_n(t + 1) = v'''_n$  about  $v_n(t + 1)$  cells:

$$x_n(t + 1) = x_n(t) + v_n(t + 1) \quad (4)$$

One have to apply every step simultaneous to every car. So we can not simulate the real situation, that the car in front can move as well simultaneous to the car behind. One can see that just step (2) has a interaction between cars and with step (3) the simulations has a stochastic dynamic. Therefore the *Nagel-Schreckenberg-model* is called a stochastic cellular automata.

Figure (3) shows a complete time step of the *Nagel-Schreckenberg-model*. In this case in step 4 we have three car which are able to hang behind but just one will to it in the next step (probability  $p = \frac{1}{3}$ ). And as one can see the speed limit in this example is  $v_{\max} = 2$ .

1. The first step in figure 3 shows that all cars want to accelerate as soon as possible to maximum speed limit.
2. the 'slow down' step (figure 3 prevent car accidents. But as mention before it does not include the movement of the car in front at the same time.
- 3.

1. start configuration



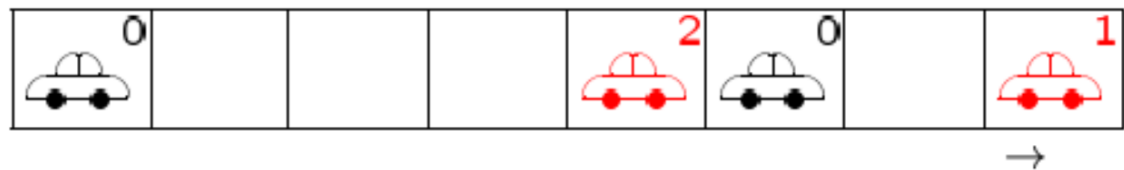
2. acceleration ( $v_{\max} = 2$ )



3. slow down



4. hang behind ( $p = \frac{1}{3}$ )



4. drive (= configuration at  $t + 1$ )

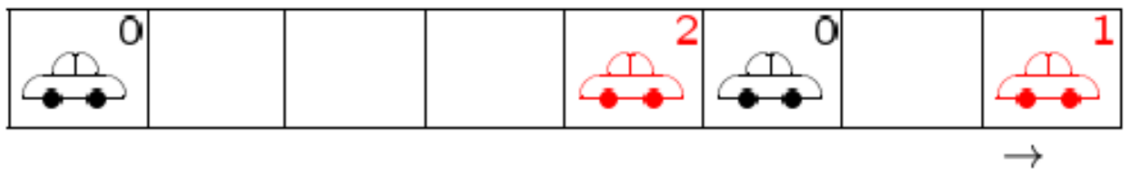


Figure 3: Shows on complete time step of the *Nagel-Schreckenberg-model* with acceleration, slow down, hang behind probability and drive.

## 6 Implementation

## 7 Simulation Results and Discussion

## 8 Summary and Outlook

## 9 References