Traffic Jam

Abbildung 1: The motorway Südosttangente on March 20th, 2019 at 3:30 p.m. at the exit at Gürtel-Landstraßer Hauptstraße (Source: asfinag.at)

Motivation

Research on traffic jams, in particular those not caused by obvious causes like car accidents or joint lanes, is crucially important topic to improve the quality of commuting in the surrounding of cities. Hereby the most important question is, which car density levels cause the fluid traffic to break down, dependent on the number of lanes and the maximum allowed velocity.

Modellbeschreibung

The most picturesque strategy for modelling of traffic jams is Nagel-Schreckenberg-Model, based on the concept of cellular automata (or gridded agent-based modelling, respectively). Hereby, the length of the street is divided into cells, each of which has space for one vehicle. In each round, all vehicles first determine where they will go, then all are moved at the same time. Each vehicle can only stand in exactly one field, so the speeds are set at fixed levels: 1 field per time step, 2 fields per time step, etc.
In a one-dimensional model - i.e. one simulated lane - a number N of vehicles is set onto the update rules are defined as follows:

1. If a vehicle has not yet reached its maximum speed, its speed is increased by one (Accelerate).
2. If the gap (in cells) to the next vehicle is smaller than its speed (in cells per lap), the speed of the vehicle is reduced to the size of the gap. (Avoid collision)
3. The speed of a vehicle is reduced by one with the probability p_d (dawning factor), provided it is not already stationary (Dawdling)
4. All vehicles are moved forward according to their current speed.

In a multidimensional model - i.e. simulating more than one lane - the following features need to be extended

1. If a vehicle is forced to brake, it can switch to this if the left lane is clear. (Overtaking)
2. If there is enough space to the right of a vehicle, it should change lanes. (Arrange Back)

Tasks

Task 1

Analyze the model analytically first: What unit has the maximum speed in the model and how does it relate to the speed of a car in the road. What speed values are accessible in the Model? How would one have to expand the model in order to obtain a finer granularity? For your implementation of the simulation experiment, specify a reasonable size for the cell length, time step and maximum model speed.

Task 2

Implement the single lane model wherein cars leave the lane on the right hand side and re-enter it on the left hand side - i.e. the number of cars remains constant. The simulation result should, depend on three parameters: dawning factor p_d, maximum velocity v_max and the number of cars N.

Task 3

Experiment with different values and perform a sensitivity analysis. Specify a quantitative measure for the fluidity of the traffic and find values $N(p_d, v_max)$ so that any $N > N(p_d, v_max)$ leads to a breakdown of it for the other parameters p_d,v_max.

Task 4

Extend the single-lane model to any number of lanes. For overtaking and re-arranging, first consider which surroundings of the vehicle need to be considered and define suitable rules.

Task 5

Extend the experiments in Task 3 accordingly to the multi-lane model.

Task 6

Document your findings in a protocol.

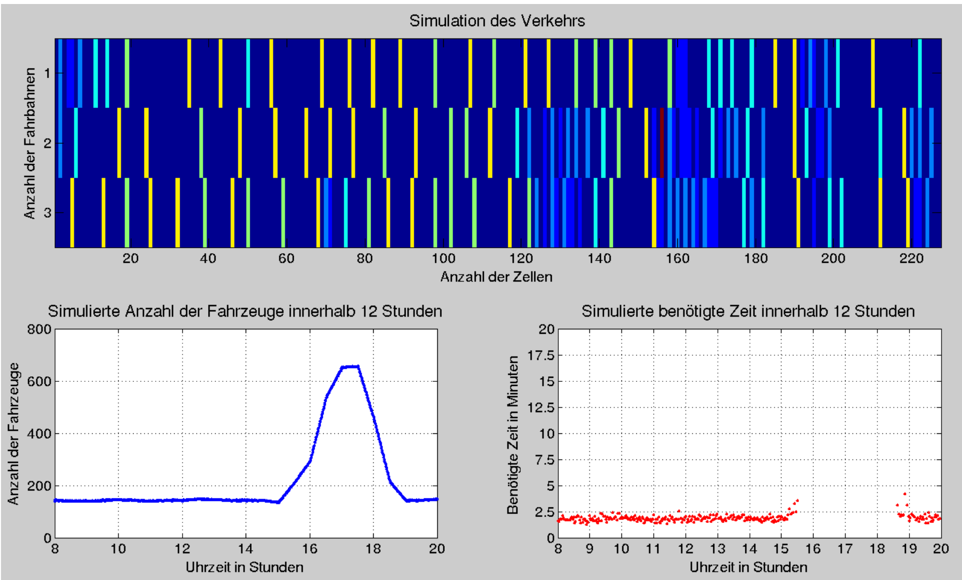

Abbildung 2: Simulation of road traffic, the number of vehicles and the travel time of a three-lane road within 12 hours.