

# Intelligent Road Control

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## 1 Introduction

An intelligent traffic control system adjusts traffic in order to assure all people reach their destinations in the most optimal time and distance. These systems are important for the daily workings of major cities by alleviating traffic congestion and identifying problem areas. It is important to constantly keep these systems updated to assure optimal performance and safety of the general public. With advancements in technology and artificial intelligence, new and more sophisticated strategies for traffic control become possible.

### 1.1 Goal

In this work, we aim to evaluate different such "intelligent" traffic control strategies and compare their effect. Thereby, we hope to identify the best working solutions to traffic jams and other occurrences (such as closing of roads/tunnels) in cities and to show their workings. We attempt to to recreate a real life city's traffic flow in order to see how these systems would work in a realistic setting. Our simulation aims to model the dynamics of a realistic environment as close as possible within the scope of the project, so that the comparison of strategies is meaningful and provides valuable data regarding the potential application of the strategies.

Our main contributions are as follows:

### 1.2 Approach

Hence, in order to test the effect of different intelligent traffic control strategies, an appropriate simulation is required. For this purpose, we created a simulation environment which allows the incorporation of different such strategies into a dynamic traffic model. Maps are realised as undirected graphs in which vertices represent intersections and roads appear as edges between those. The simulation is *microscopic*. That is, instead of globally controlling traffic (*macroscopic*), the atomic parts of the simulation are locally controlled cars (see also Krajzewicz u. a., 2002). Driving behaviour is modelled using the time- and space-continuous *Intelligent Driver Model* (IDM) (Treiber, Hennecke und Helbing, 2000).

### 1.3 Related Work

There has been extensive work on the simulation of traffic flow as well as the development of traffic control strategies. Following up on different approaches on

modelling car following behaviour (e.g. Gipps, 1981), Treiber, Hennecke und Helbing (2000) developed the influential Intelligent Driver Model for the simulation of urban traffic. Similarly to the former, it creates a collision free environment where cars mind the a spacial and time-wise gap to the leading vehicle. The SUMO package (Krajzewicz u. a., 2002; Behrisch u. a., 2011) utilizes the model by (Gipps, 1981) in an extended version (Krauß, 1998) in a complex simulation software. In contrast to their work, we use the IDM. Hence, our simulation is (quasi) time-continuous, rather than time-discrete.

In the following sections we further describe our approach and the results of our experiments. We begin by elaborating on the implementation of the simulation environment (section 2), followed by a description of different control strategies (section 3). Following, we describe the experiments we conducted for those strategies and our evaluation methodology (section 4). In section 5 we will report the results of these experiments. We conclude this work by discussing our results and proposing future directions.

## 2 Simulation Environment

In the following subsections we describe the implementation and design choices of the simulation environment in which we evaluated the effect of different traffic control strategies.

### 2.1 Graphical User Interface

The Graphical User Interface (GUI) is designed for simplicity. It consists of three panels. On the left side the main panel is located. Here, maps can be created and navigated through and the simulation process is visualized. Maps can be interactively constructed by clicking and dragging on the panel. Above the main panel there is an info panel that indicates different values such as the current time and day of the simulation. Finally, the right panel contains the controls for different functionalities such as the creation of maps, setting of experimental parameters and controlling the simulation. Figure 1 shows this interface with a small map.

### 2.2 Traffic Flow Simulation

As mentioned beforehand, we apply the IDM (Treiber, Hennecke und Helbing, 2000) for the simulation of car dynamics. It models traffic flow time- and space-continuous as a combination of *free-road* and *interaction* behaviour. The *free-road* term is governed by a



using the thinning algorithm by Lewis und Shedler (1979). The data used is shown in figure 2. As can be observed, this creates rush hours around the hours of 8 to 9 am and 5 to 6 pm.

### 3 Traffic Control Strategies

In this section, different traffic control strategies are highlighted as well as their effectiveness in different environments.

#### 3.1 Benchmark Strategies

#### 3.2 Coordinated Traffic Lights

Coordinated traffic lights are traffic lights that exchange information with each other in order to predict future traffic patterns and assure the least amount of congestion possible. Each intersection is outfitted with different types of sensors, depending on the environment in which they are needed. These sensors can include inductive loops, cameras, or microwave radar systems, each of which has its own pros and cons.

The coordinated traffic light strategy currently implemented uses features resembling that of a microwave motion sensor. The reason of using this type of sensor is mainly because the detection range can be altered to each one depending on the area it is installed, the ability to accurately detect distance of vehicles, and also it is able to tell if cars are moving towards or away from it. Other reasons for implementing this type of detection system is that in real-world situations, this device can be installed above ground, which greatly reduces cost of installation, and can also be installed very quickly at very low charge and cause minimal traffic disturbance.

This type of traffic control system is preferred for areas with minimal obstructions (such as road signs or buildings). Since our current traffic simulation does not have any external obstructions other than cars, this is the best strategy to use. In cases where many obstructions are in play, it would be more recommended to use inductive loops (commonly thought of as 'pressure plates' installed into the road, but quite costly).

### 4 Methodology & Experiments

In order to be able to measure and compare the efficiency of the different strategies applied, various measurements are taken while the simulation is running. One of these is the average speed of the vehicles for each road. Measuring this is done by starting a timer for a car when it enters a road and stopping it when it leaves it. Then, by using the following formula, the average speed is calculated:

$$v = \frac{s}{t} \quad (4)$$

where  $v$  is the velocity,  $s$  the road length and  $t$  refers to the time spent on a road. Using this, we can also easily derive the average speed on each road. The second

statistic measured is the amount of time each car spends waiting at traffic lights. This is achieved by checking at each time step if a car is under a certain speed and is not accelerating. Whenever the previous conditions are fulfilled, the total amount of waiting time is increased by the size of the time step. The purpose of the control strategies is to maximize the average speeds and minimize the time spent waiting in congestions.

#### 4.1 Simulation Validation

In order to validate both the IA generation as well as the general behaviour of different measures and dynamics, we validated the simulation environment using the average speed of cars, their number on the map as well as fractional waiting times in the simulation as a development over one day. Figure 3 shows the results in three graphs. As can be observed, not only the density, but also both other dependent measures resemble the rush hour pattern from the original data.

### 5 Results

### 6 Discussion

### 7 Conclusion

### Literatur

- Behrisch, Michael u. a. (2011). "SUMO-simulation of urban mobility: an overview". In: *Proceedings of SIMUL 2011, The Third International Conference on Advances in System Simulation*. ThinkMind.
- Gipps, Peter G (1981). "A behavioural car-following model for computer simulation". In: *Transportation Research Part B: Methodological* 15.2, S. 105–111.
- Kesting, Arne, Martin Treiber und Dirk Helbing (2007). "General lane-changing model MOBIL for car-following models". In: *Transportation Research Record: Journal of the Transportation Research Board* 1999, S. 86–94.
- Krajzewicz, Daniel u. a. (2002). "SUMO (Simulation of Urban MObility)-an open-source traffic simulation". In: *Proceedings of the 4th middle East Symposium on Simulation and Modelling (MESM20002)*, S. 183–187.
- Krauß, Stefan (1998). "Microscopic modeling of traffic flow: Investigation of collision free vehicle dynamics". Diss.
- Lewis, Peter A und Gerald S Shedler (1979). "Simulation of nonhomogeneous Poisson processes by thinning". In: *Naval Research Logistics (NRL)* 26.3, S. 403–413.
- Office of Highway Policy Information - Policy | Federal Highway Administration. URL: [https://www.fhwa.dot.gov/policyinformation/tmguid/tmg\\_2013/traffic-monitoring-methodologies.cfm](https://www.fhwa.dot.gov/policyinformation/tmguid/tmg_2013/traffic-monitoring-methodologies.cfm) (besucht am 28.05.2018).
- Treiber, Martin und Dirk Helbing (2002). "Realistische Mikrosimulation von Strassenverkehr mit einem einfachen Modell". In: *16th Symposium Simulationstechnik ASIM*. Bd. 2002, S. 80.
- Treiber, Martin, Ansgar Hennecke und Dirk Helbing (2000). "Congested traffic states in empirical observations and microscopic simulations". In: *Physical review E* 62.2, S. 1805.

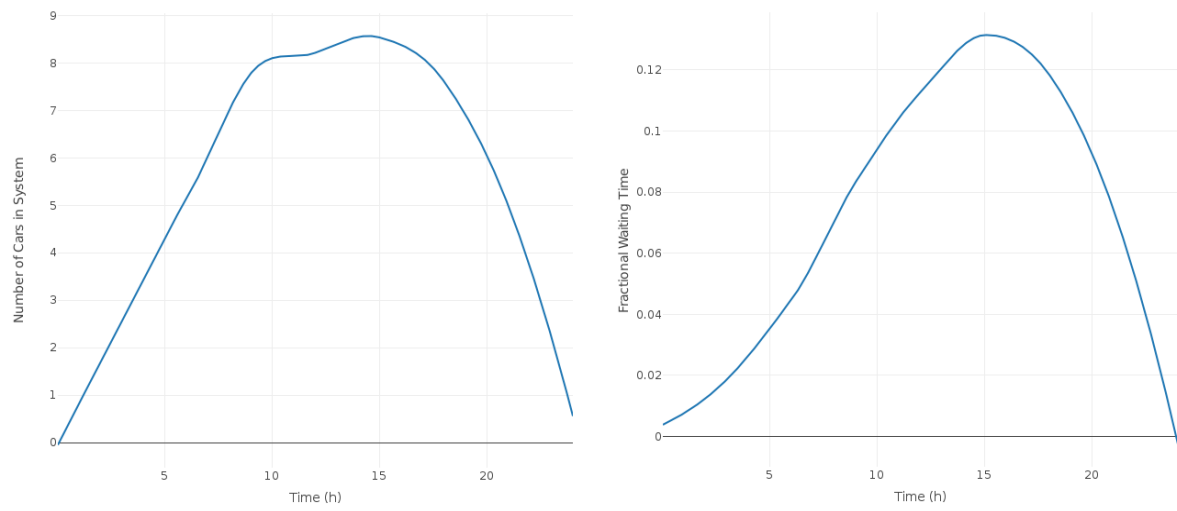


Figure 3: Number of cars (left) and average fractional waiting time of cars (right) in the system simulated for one day. IATs are generated from the empirical distribution shown in figure 2