Tuning of Feedback-based Traffic Light Controls

The growing traffic demand in cities is an increasing problem since in many cases the roads cannot be further developed to increase the capacity. Therefore, more advanced controllers of traffic lights need to be conceived of and implemented. With more smart sensors in the roads, one can implement more sophisticated control schemes. This thesis investigates how different environmental conditions might affect the tuning of a decentralized controller – a controller that only has information about the junction in which it operates.

The fundamental problems with vehicles in a junction are that they can collide and if they have stopped to give way for others, they then need time to accelerate. The collision problem is solved by introducing traffic lights and assigning different lanes green light at different times. However, this solution together with the need to accelerate produces an artefact, namely that it takes some time before a queue of vehicles start does drive at optimum speed. The consequence of this is that every time a traffic light goes from red to green one loses some time that could have been used to empty the queue. This loss of time, traffic engineers usually call start-up lost time. If drawn to the extreme – traffic lights flashing like disco lights would mean that no vehicle can drive and therefore that the number of cars the junction can handle is zero. On the other hand, if the lights switching intervals are very long, drivers might have to wait until tomorrow to drive which is not very good either. Somewhere in between is the optimum between having enough capacity for vehicles in the junction and cars not having to wait for too long. How to achieve this?

One of the original strategies to control traffic lights was to estimate the traffic demand and then implement a schedule of greens and reds entirely without any knowledge of the traffic situation at the moment. Since in many cities the traffic demand will vary throughout the day in a not always predictable way, this is an imperfect solution. Instead, to better match the current situation, one can use adaptive controllers which will vary the time of the green lights according to the momentary traffic demand. However, these controllers need to be tuned. In this thesis, we address the problem of how to tune a family of controllers to archive good performance. We also discuss what a suitable performance measure is.

To address those problems, we use a micro simulator called SUMO. A micro-simulator is a simulator that simulates each car's behaviour. When doing a mathematical analysis of the traffic light problem, it is often too complicated to analyse the behaviour of every single vehicle. Therefore, a micro-simulator is very useful to perform a more realistic analysis.

The results show that, in general, the size of the traffic network does not matter if the traffic demand scale accordingly, that the layout of the junctions profoundly affects the choice of tuning parameters and that the controller adapts well to different traffic demands. Our analysis also shows that the lengths of the sensors measuring the queues will have a significant impact on the tuning. From the simulations, it seems that a sensor that can measure queues of up to 60 meters is needed not to impact the optimal tuning too much. A sensor that is too short can even make the queues grow uncontrollably large. Hence, if the sensors one is using only can measure short queues more sophisticated methods, for example, different estimation techniques, are needed to archive good performance.