Using traffic signal control in a connected vehicle environment to influence multiple performance indicators

Master's Thesis of Sebastian Gutmann

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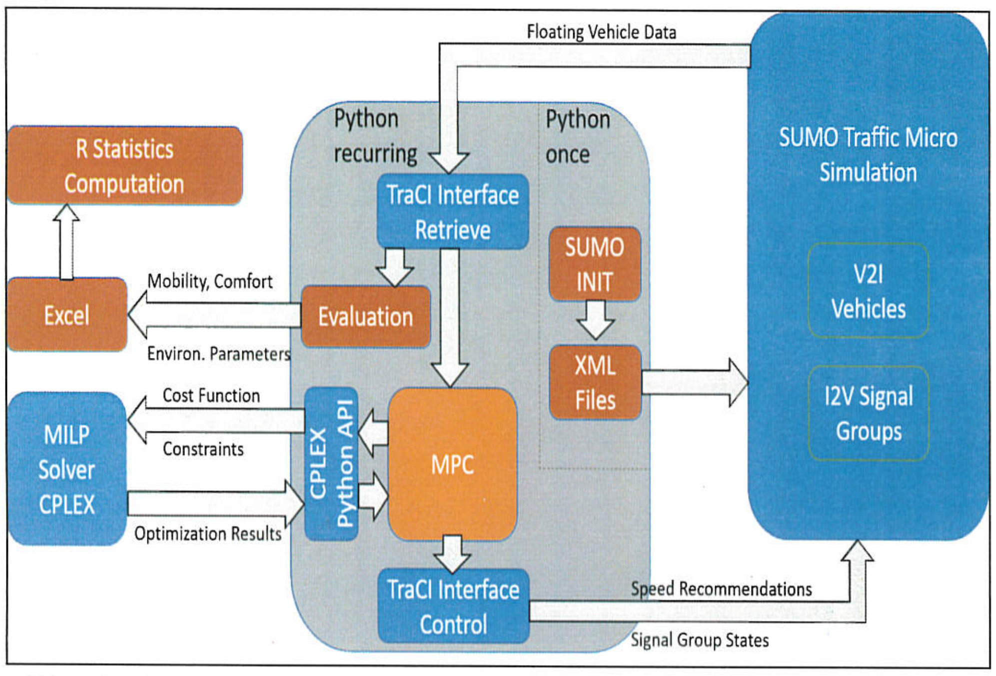

Fig. 1 Overview of simulation, optimization and evaluation modules

The aim of this thesis is to research how increased data availability of connected vehicle environments can improve urban traffic conditions. The connected vehicle environment is simulated with an adapted model predictive control (MPC) algorithm that mutually optimizes fully adaptive traffic lights and vehicle trajectories. Connected vehicle environments provide large amounts of data such as vehicle type, propulsion system, occupancy, etc. The question then arises of how to use this data in order to implement different municipal policies. Therefore, the potential of connected vehicle environments is researched without initially following any specific policy. The nature of providing efficient green-light-optimized speed advisory (GLOSA) messages is studied by smoothing the approach trajectories as well as choosing appropriate speed message ranges. Second, existing municipal policies and current research approaches are organized into policy clusters. One exemplary policy strategy from each cluster is then implemented and evaluated within a multi-criteria analysis.

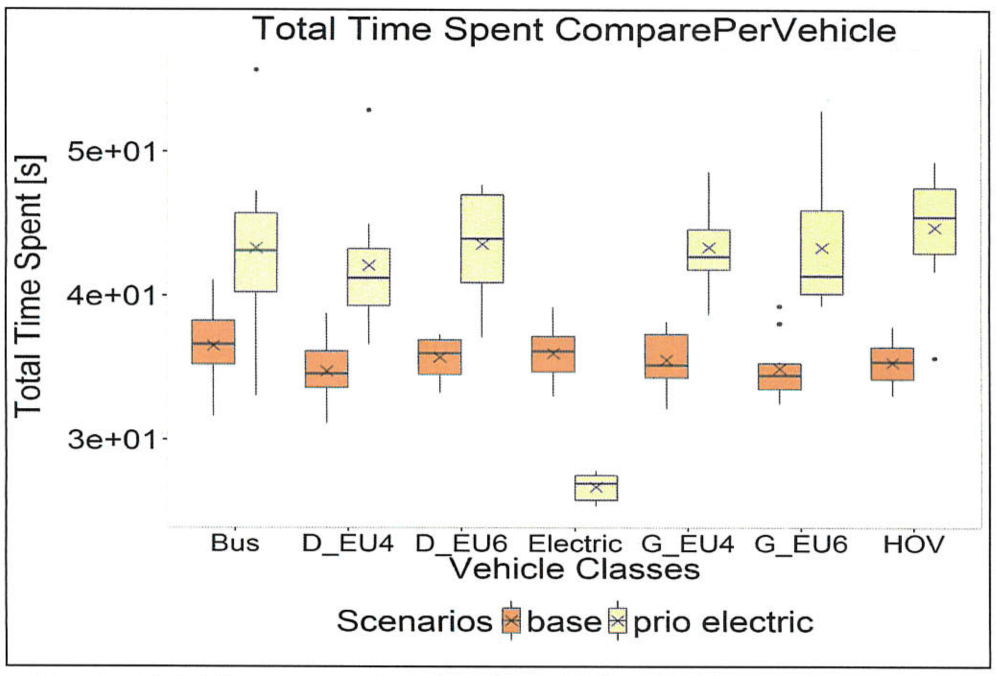

Fig. 3 Total time spent for electric vehicle prioritization scenario

Problem Definition

- In connected vehicle environments the available information will increase excessively
- Not only public transport vehicles, but also passenger cars can provide information to traffic signals
- The question arises which vehicle attributes to use and how to balance green times of different road participants

Research Objectives

- Definition of meaningful urban policies and respective performance indicators
- Extension of an existing control method to allow for weighting within a mixed-integer linear programming cost-function minimization problem at microscopic level
- Development of automated statistical evaluation framework for multi-criteria and multi-level analysis

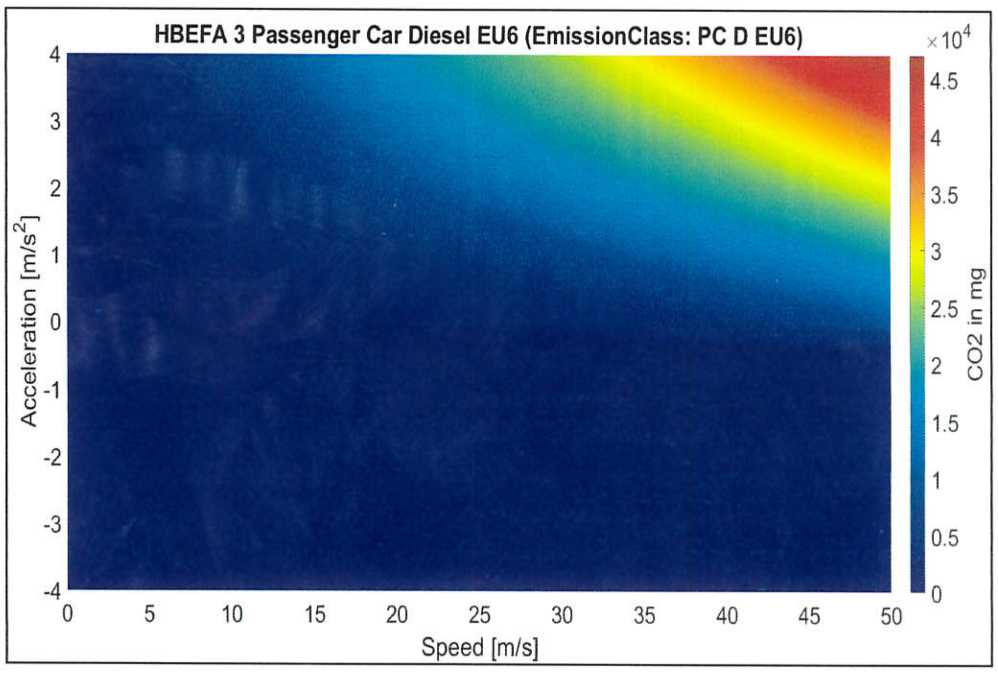

Fig. 2 Dependence of CO_2 modelling upon speed and accel.

The criteria are mobility, comfort and environment. The uniqueness of this study is the comprehensive evaluation of prioritized vehicles, non-prioritized vehicles and total scenario effects. The results indicate that connected vehicle environments offer significant potential to enlarge the scope of urban policies. However, each interference caused by prioritizing a number of road participants leads to disturbances for the remaining ones. As a consequence, the effects for both the non-prioritized users as well as on a comprehensive level, differ greatly depending on the chosen policy. In summary, the optimal policy discovered focuses on people flow, which is achieved by prioritizing the dynamic vehicle attribute occupancy. Disturbances are kept relatively low and at the same time NO_x emissions are reduced by -15 % when compared to the base scenario.