Interactive Front-End for EV Traffic Simulation in Highways

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ABSTRACT

As set in the OECD Environmental Outlook to 2050 [1], CO_2 reduction will be a major target for the OECD nations in the near future. Even though electric vehicles [EV] could play a big factor in achieving that goal, their sales are strikingly low in Germany. Only 0.39% of new car registrations were EVs in 2015 [2].

A decisive disadvantage of EVs is their generally low range of 150 km or less. In order to still efficiently travel long distances of 500 km and upwards, Victor del Razo and Hans-Arno Jacobsen outlined a method in their paper "Smart Charging Schedules for Highway Travel with Electric Vehicles" for scheduling charging stops on a highway, such that the total travel time is minimized [3].

They developed a simulation framework that is in need of a graphic interface for the manager of the simulation. Additionally, a UI for the EV driver is required. It should display certain information, such as the EV's current position on the map or the upcoming charging stations.

Therefore, this work comprises two prototypes for the respective frontends: a driver user interface [DUI] and a simulation managing user interface [SMUI].

1. INTRODUCTION

Comfortably traveling longer highway routes with an EV is currently a challenging endeavor. The charging infrastructure is still nascent, which potentially causes already long charging times to be prolonged by having to wait for a free spot at a charging station that runs at full capacity.

The whitepaper "Smart Charging Schedules for Highway Travel with Electric Vehicles" [3] by Victor del Razo and Hans-Arno Jacobsen first and foremost proposes a scheduling approach for EVs to decide on their charging stops during a trip on a highway where the charging infrastructure is limited. The goal is to reduce the total travel time for each EV. It then introduces a simulation framework that demonstrates the smart scheduling approach and on top of that aids the simulation process by providing generated trip data and support for time-dependent parameters that effect highway traffic.

In the following, the general idea of the scheduling approach and the resulting mathematical model will be briefly outlined, mostly pertaining to the aspects that are relevant for the simulation tool. The problem is formulated as a shortest path problem and the scheduling algorithm is based on the A* search algorithm, which is extended with verification of constraints, such as EV energy limitations and driving speeds.

The model has three main components: EVs, a highway and charging stations. The scheduling strategy is local to the EV but requires real-time communication with charging stations and a general highway-related information system. A set of charging stops and times is calculated and the relevant bookings are submitted to the charging stations together with the expected arrival time. The trip proceeds as planned unless an update schedule event is received.

The EVs do not interact directly with each other, however, they indirectly influence each other via relying on the communicated information from the charging stations on their current occupancy level and the state of their reservation system. The reservation system supports dynamic updates as hinted at earlier.

The simulation tool implements a representation of the described model and its behavior. Additionally, it accounts for highway exits/entries, variable highway speed limitations, and EV-specific characteristics.

Our task now is to design and implement a graphic interface that shows the states of all EVs and charging stations on the highway as they develop during the simulation. Moreover, an interface for the EV driver, that presents all relevant vehicle and travel related information, should be conceived.

2. RESEARCH

Our main research question is as follows: What is the most suitable form of presentation for the data that is most relevant during the simulation and while driving respectively?

There are a variety of aspects that need to be considered when designing a frontend for data-heavy applications, such as the highway traffic simulation tool we are dealing with. Perhaps most importantly, all relevant data pertaining to the state of the models used in the simulation should be accessible in a structured way that is intuitive for the user.

Depending on the size of the simulation in terms of EVs and charging stations, this is not a trivial task. More advanced considerations include how to illustrate relations between EVs and charging stations, how to visually communicate schedule changes to the user and how to present certain metrics in an aggregated form.

The design of a user interface that is going to be used in an EV on the other hand, poses a completely different set of challenges. In our research, we will have to look at best practices for this specific use case in which the user can only take in a limited amount of information. The key will be to determine when to present which piece of data to the user. Certain crucial information points should most likely always be visible while others only occur when they are relevant in the context of time and location.

A further part of our research will be getting an overview of the tools and frameworks that might help us in implementing our two interfaces and finally determining which if any is most suitable for our requirements.

3. PRELIMINARY LITERATURE REVIEW

Automotive User Interfaces have been around since decades, consequently our goal will not be to reinvent the wheel but to examine existing standards and stick to those. Especially the ones ISO [International Organization for Standardization] offers are a good source when it comes to recommendations and best practice. The ones defining an automotive user interface are worth mentioning [4].

Standard	Description
ISO 15005:2002	Dialogue management principles and compliance procedures
ISO 15006:2011	Specifications for in-vehicle auditory presentation
ISO 15007-1:2014 2:2014	Measurement of driver visual behaviour
ISO/TR 16352:2005	Warning systems
ISO 16673:2007	Occlusion method to assess visual distractio
ISO/TS 16951:2004	On-board message priority
ISO 26022:2010	Simulated lane change test to assess distraction

Obtaining those standards is not easy and cost intensive, thus it is unsure at this point how and if we can get access to them. Design knowledge, when it comes to user interfaces, plays a key role, especially in vehicles, where distraction is a big factor [5].

Another aspect that needs to be taken into consideration in vehicles is situation awareness [6]. A current challenge is the integration of different heterogeneous user interfaces into existing systems [7]. This also applies to our prototype, since we need to keep in mind that it might be integrated into an existing system in the future.

4. REQUIREMENTS

Driving user interfaces have often proven to be complicated or not so well integrated, therefore in our approach we will try to keep it as minimalistic as possible but still have all necessary features onboard. Most important for the driver UI are the own stats like time, current position of the car, probably integrated as a map with a display of possible charging stations around, the time and distance already traveled and the current speed of the vehicle.

Furthermore, EV specific statuses, such as the time waited for charging, the current battery level as well as an estimate of charging time and specific to the simulation the schedule status. This means that the user will always be able to tell what the battery status is, his distance to the destination as well as the distance to the next scheduled stop, so that he has an overview of the remaining trip.

Besides the staus display, a functionality will be integrated, so that the user can enter a destination and the system can then calculate the optimal charging route. In addition, it will then display the route and show the user scheduled stops. While the user is driving, there will be some sort of notification, so that he is informed in time, when he is getting close to a stop.

The simulation user interface will show an overview of all charging stations. It will give detailed information for each charging station, so that he can follow the stations' development. Information about the scheduling algorithm will be the main focus here, like queue length, queue prediction of waiting cars, busy poles, arriving and departing cars and those that are currently plugged in.

Furthermore, information about energy management will also play a key role, such as energy consumed, energy produced, energy stored and energy bought. Another information that will be provided is important data about a current charge event, such as the duration or charging technology used. A main focus for the simulation user interface will be providing aggregated and cumulative statistics about the EVs and charging stations.

5. RESULTS

The primary goal of our project is to fulfill the aforementioned requirements. They specify the desired functionality that we aim to realize during the design and implementation of the frontend for the simulation manager and the EV driver respectively.

The result of our work will be in the form of two prototypes that can be tested by a user in order to assess whether the promised functionality was indeed delivered.

6. TIMELINE

Objective	Time	Deadline
Phase 1: Proposal	**2 weeks**	**2016-11-16**
First research and examination of literature sources	6 days	
Research context and background	5 days	
Draft a 2 page proposal	3 days	
Phase 2: Prototyping	**8 weeks**	**2016-01-11**
Driver user interface concept & mock-up	1 week	
Driver user interface prototyping	3 weeks	
Simulation managing user interface concept & mock-up	1 week	
Simulation managing user interface prototyping	3 weeks	
Phase 3: Presentation	**1 week**	**2017-01-17**
Create slides for 30 min presentation	1 week	
Phase 4: Report	**5 weeks**	**2017-03-05**
Write 20 page final report	5 weeks	

7. REFERENCES

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