Experience Maps: Experience-Enhanced Routes for Car Navigation

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Abstract
People spend a considerable time per day driving a car. Navigation technology helps the driver to find a location, to see traffic details, or to estimate the arrival time. Selecting a certain route influences the driving experience (i.e., the user experience while driving) through factors such as traffic density, landscape, or road type. However, current navigation systems mainly optimize routes regarding time, distance, or fuel efficiency–neglecting important driving experience factors: The fastest route might still be packed with traffic which stresses drivers or negatively influence their mood. In contrast, a slightly slower route could for instance offer a better driving experience with less traffic and scenic views. In this paper, we propose a concept that allows for experience-optimized routing to make driving more joyful and pleasurable. We also present the results of a web survey with 114 participants that we conducted to explore the users' preferences and opinions regarding taking the experience into account for route guidance.

Author Keywords
Automotive user interfaces; car navigation; driving experience; route guidance; user experience.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces

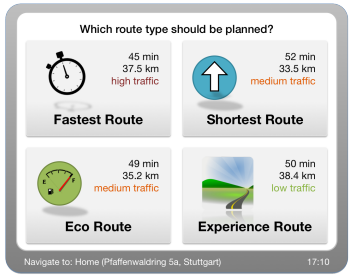

Figure 1: Prototypical screen for an experience-enhanced routing: Experience Routes aim at increasing the driving experience by considering experience-enhancing factors (e.g., traffic density, scenic routes) during route calculation

Introduction

GPS navigation systems, either as built-in or portable devices or as smart phone apps, are commonly used while driving a car. Showing the way to a foreign location, informing about the arrival time, or presenting the current traffic situation and speed limit are some of the most important features offered by current software. The navigation software calculates the route from the current location to the entered destination. In current systems, important criteria to optimize these routes are duration, distance, fuel efficiency, and real-time traffic information.

Many car manufacturers do not only advertise the technical highlights of their cars but also underline the *driving experience* of their cars. While they often base this driving experience on the technical features of a car (e.g., a powerful engine), we think that there are more (route-dependent) factors that influence the driving experience. For instance, surrounding traffic, road properties (e.g., speed limit, surface, curvature, number of lanes), landscape, as well as weather influence workload and perception of a driver, and, hence, the driving experience. Thus, the selection of a certain route can have a large impact on the perceived driving experience. Often, various routes to a destination differ only slightly with regard to duration and distance. However, besides real-time traffic information and the possibility to exclude specific roads (e.g., toll roads and highways), many of these factors that influence driving experience are not directly taken into account in current navigation systems. For instance, road curvature might influence the automatic route selection regarding travel time, but other effects are not yet considered. Thus, a route with a much higher driving experience (e.g., a more scenic route) might be discarded although it is only a few minutes longer than the fastest route.

We propose a concept that extends the factors taken into account for calculating car navigation routes by those factors that enhance driving experience. Such *experience-enhanced routing* (cf. Figure 1) shall increase driving fun, relax the driver, and, thus enable an increased driving experience–by only changing the selected route. Our overall goal is to identify and consider those factors that influence driving experience most. As a first step, in this paper we present the concept of experience-enhanced routing. We report the results of a web survey on driver's needs and opinions about car navigation and experience-enhanced routes to evaluate the concept. Also, we propose ideas how to crowdsource and collect experience-related information in the real world to create a comprehensive data set to be used in future experience-enhanced routings.

Related Work

Most car navigation systems today optimize routes regarding time, distance, or fuel efficiency. Current algorithms already consider several static or dynamic context and road parameters (e.g., distances, speed limits, road curvature as with TomTom Rider[1], and current traffic situation) to calculate and update a route (e.g., [2]). As traffic changes during the day, technologies such as TomTom HD Traffic and IQ Routes [11] integrate both historic and live traffic data when calculating a route. The employed real-time data is gathered automatically (e.g., through road sensors) or manually updated by operators. Also, initial concepts exist to adapt routing algorithms to personal driving preferences [7]. However, experience-enhanced route optimization based on large-scale real-world data has not been implemented so far.

When it comes to pure enjoyment of driving, traditionally tour books proposed trips along scenic roads, certain points

[1] `http://goo.gl/Lx0Cr3`, Last access: 2014-08-07

of interest, and roads that are "fun to drive". Portals such as the BMW Route Portal[2] took over this idea to the digital world. However, people normally drive such routes only as a leisure activity. Instead, we aim at also improving the everyday driving experience. Projects such as EmoCityMap[3] measure and communicate people's emotion as a response to the current location and surrounding. Based on physiological data, face&body tracking, the Senseable City Lab investigates emotive aspects of driving to calculate a "road frustration index"[4]. While the retrieval of such information is a first step, our goal goes beyond such concepts: The idea is to not only measure the driver's emotion at specific areas or during certain situations, but to do so for the full road network and use this data as additional weights for roads when calculating routes in order to increase driving experience.

Researching User Experience (UX) with automotive navigation systems has been in the focus of HCI recently. Forlizzi et al. [3] suggested to include the social nature of navigation into the design process of new navigation systems. Brown and Laurier [1] showed that drivers do not necessarily follow navigation systems blindly but that we need to understand the interplay between drivers, passengers, and GPS systems for a better design. Münter et al. [6] investigated a concept to adapt the route presentation and information to the driver's needs and, thus, increase driving experience. They adapt routing instructions (e.g., levels of detail) based on the driver's knowledge of a route and the current driving conditions. However, they only adapt the route presentation and navigation support, but do not change the route to increase driving experience.

[2] `https://www.bmw-routes.com/`, Last access: 2014-08-07
[3] `http://www.emocitymap.com`, Last access: 2014-08-07
[4] `http://senseable.mit.edu/rfi/`, Last access: 2014-08-07

Concept: Experience-Enhanced Routing

As we see that driving experience is getting a factor that is more and more important, we propose a concept for route guidance that enhances routes to provide a better driving experience ("joy of driving"). Driving experience in this sense can have different aspects such as ease of driving, fun of driving, and the driver's workload.

The idea is to use additional details about road segments (e.g., difficulty of the road, drivers' emotional response, physiological data) that indicate an influence on driving experience as additional road weightings when calculating routes. So far, mainly details such as current or historic traffic, speed limit, number of lanes, curvature, incline, and route length are taken into account to optimize routes with regard to shortest time, distance, or fuel efficiency.

Additional measurements such as physiological data, driver's ratings, and additional context data (e.g., weather, time of day, landscape, road difficulty, traffic composition) provide ways to infer the driver's workload and emotional state, which also influence the perceived driving experience. By combining traditional route-influencing factors with these additional measurements, we want to optimize the overall driving experience. We assume that the collected data influences the route calculation and, hence, leads to an experience-optimized route that contains less stressful and more enjoyable moments.

A specific route could for instance increase the driving experience because of a beautiful view of the sunset whereas other routes decrease the driving experience because of a dazzling sun. Also, a route might guide through a beautiful landscape or along roads that were positively rated by other drivers. The intention of an experience-enhanced route is that the driver arrives more happily and less stressed at their destination.

Suitable methods need to be used that allow to collect and evaluate the above mentioned additional measures and to predict the driving experience on a certain road segment. We imagine that the methods and sources mentioned below are suitable means to collect the information that will later allow an experience-enhanced navigation.

Sources of Experience Data
We see three different sources to collect information regarding the experience of the drive, namely objective contextual data, objective physiological data, and subjective direct user feedback. These three types of data are closely related to each other. Context factors may influence both physiological responses as well as the subjective assessment of the situation.

Contextual Data
The current driving context influences the driver's situation. This includes all relevant parameters, such as the current traffic situation, time of day, road design, purpose of the ride (e.g., commuting vs. vacation), social context (number of passengers, their relation to the driver), and weather conditions. These factors might influence the driver's workload and the driving experience. Similar as existing navigation solutions consider historic and current traffic and speed information as road weightings for estimating the time of arrival, we want to use such information – enriched by data as mentioned before – to increase the driving experience on calculated routes.

Physiological Sensing & Data
As shown in literature, physiological data can inform about the driver's workload or emotional response [9]. Hence, one approach will be to anonymously collect such data while driving. Although current systems still require to "wire up the driver" first non-invasive technologies (e.g., [10]) and smartphone apps evolve that can measure physiological data or cognitive load and emotional state of the driver [8] without additional effort.

Subjective User Feedback
Besides physiological data we see the urge to gather subject feedback from drivers. This means that the drivers will have the chance for a subjective assessment of a situation and their emotion when the situation is actually happening. We will aim for a subjective assessment of the situation and the influence of the context on the user experience, as well as, the general user emotion. Since the gathering of subjective during a real-world driving situation is crucial in terms of ethical considerations, we will have to take care to not distract the driver from the primary task of driving.

Method of Data Sampling
In order to gather data in-situ and to combine the different data sources we want to utilize an adaption of the Experience Sampling Method (ESM) [4]. ESM is an in-situ method to get constant user feedback in real life situations and has already successfully been adapted to the car context [5]. An ESM client (e.g., a smart phone) could be installed in the car to collect data from different sources (e.g., context data from smartphone sensors and the car's OBD-II interface; physiological data). It can also be utilized to visualize ESM questions in appropriate situations (e.g., displaying them on-screen or reading out the question loud) and collect driver's subjective assessments (either using the touchscreen or allowing verbal answers). By embedding mechanisms to geo-tag road segments with these measurements, experience parameters can be gathered.

Web Survey: Exploring Driver's Needs

To gain insights into which factors drivers rate as important and to investigate what drivers think about experience-enhanced navigation, we conducted a web

Factor	Mdn	Mean
fastest route	1	1.57
least stress	2	2.00
least traffic	2	2.06
precise arrival time	2	2.16
least fuel consumption	2	2.43
no toll	2	2.62
shortest route	3	2.96
easy route	3	3.61
only few trucks	3	3.67
no speeding traffic	4	3.90
known route	4	3.91
well rated route	4	3.96
highest driving experience	4	4.20
scenic route	4	4.40
low curvature	4	4.54
nice POIs	5	4.83
unknown route	5	4.90
challenging route	5	5.26
no highway segments	6	5.54

Table 1: The participants' importance rating of factors that may influence drivers' route selection. The factors are ordered by the medians of the 7 point Likert scale importance ratings from our web survey (ratings from 1 "strongly agree" to 7 "strongly disagree"). Factors with the same median were also sorted by their means.

survey. The survey was publicly available and invitations to participate were distributed via e-mail, Facebook, faculty mailing lists, and learning platforms. Our goal was to gain knowledge about current driving and navigation preferences. We also asked concrete questions about using experience-enhanced routes. In total, 114 participants aged from 17 to 80 years ($M = 29.82$, $SD = 11.4$) took part in this survey. All but two had a driver's license and 89.5 % drove a vehicle at least multiple times a month.

The survey consisted of two parts. First, we asked the participants how important several factors for their route selection process are. These factors (cf., Table 1) had been identified beforehand in an expert brainstorming with 3 automotive researchers and were then used in our survey. In the survey, each of these 19 factors was presented as a statement (e.g., "It is important to me to drive the shortest route.") and could be rated from 1 (strongly agree) to 7 (strongly disagree) on a 7-point Likert scale. As a second part, we asked the participants to imagine that they want to drive home from work in 20 minutes and presented the prototypical navigation screen as shown in Figure 1 where different routes to their destination were proposed – including an experience-enhanced route. We asked which of the routes the participants would select and asked for qualitative feedback regarding their choice and the circumstances under which they would do so.

Results

Regarding the importance of the different factors for the participants' route selection process, Table 1 gives an overview on the participants' ratings, ordered by their median and mean values (for factors that have the same median): The drivers considered the fastest route ($Mdn = 1$) as most important. Further, they considered arriving with little stress as important ($Mdn = 2$, 2nd place), which can be seen as a factor influencing the overall experience. In the 3rd place, lowest traffic ($Mdn = 2$) was mentioned as an important factor.

When the participants had to select a route for their drive home in the second part, surprisingly 49.1 % selected the fuel-efficient route, while 28.9 % preferred the experience-enhanced route in the presented example (fastest route: 18.4 %, shortest route: 3.5 %, cf. Figure 2). Among those that selected the fuel-efficient route, participants argued that they rated fuel efficiency as more important when the time difference to the fastest route is low (as in the given example). Also the traffic indication was given as a reason to not select the fastest route: "*high traffic* indicates that the fastest route will take longer than calculated" (P#18).

Regarding experience-enhanced routes, one participant argued that they *want to arrive relaxed at home after work* (P#92). Other reasons for choosing this route were *enjoying the sun* (P#104), *getting to know the surrounding* (P#25), *driving or testing new cars/convertible* (P#7) or *going on vacation* (P#109). Nevertheless, most participants clearly stated that they would only use the experience route if they do not lose much time (e.g., *the difference in time and distance are too small to be the decisive factor*, P#60). We also asked about how much the participants would allow the time or distance of an experience-optimized route to be longer than the shortest or fastest route. On average, the participants would allow an experience route to take 20.9 % longer with regard to time and fastest route ($SD = 21.3\%$), respectively 25.7 % with regard to distance and shortest route ($SD = 28.2\%$).

Conclusion and Future Work

Driving experience is becoming an important factor for driving a car. Our web survey shows that not only factors

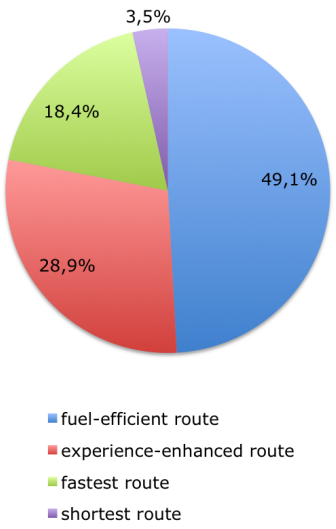

Figure 2: Drivers' preferences regarding route selection when driving home from work.

like shortest time, arrival time arrival, and fuel consumption are important to the driver. Similarly, drivers prefer low traffic density, low workload and stress level, which are typical factors that increase driving experience. The qualitative feedback shows that the preference of a certain route depends on the current situation and, hence, might be different from time to time. Already today, drivers seem to not only focus on the fastest route. As even small changes with little effects on time and distance might improve the driving experience, we think that the investigation of experience-enhancing factors will be very beneficial for drivers.

As a next step, we plan to create a navigation system that considers the proposed experience factors. Therefore, the first challenge is to collect experience-related data and to identify the experience-influencing factors. Hence, we started developing a prototype that collects a subset of the proposed real-world data. Data from all three categories should be collected, namely, physiological, contextual, and experience-sampled data. One of the key sources of information is the data gathered through the experience sampling of the user. The prototype will consist of a mobile phone application that simply asks the driver, once a full stop is detected, how enjoyable the last route segment was. Additionally, the prototype will be able to collect contextual data (e.g., brightness, acceleration) and some physiological data (e.g., emotion detection through the camera). Our idea is to deploy the prototype in the wild to get insights into how drivers perceive specific routes and to build up a comprehensive dataset of experience-related road factors.

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