Location Based Challenges on Mobile Devices for a Fuel Efficient Driving Behavior

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Abstract. Motivating car drivers to change their habitual driving behavior toward a less fuel consuming way is an ambitious task. In this paper a game like approach based on the concept of location based challenges will be presented in order to allow drivers to compare their fuel efficiency with other drivers of the same route section in real-time. A mobile device display was used to provide feedback on drivers' current status with respect to efficiency and community ranking. A first explorative field study shows promising tendencies in terms of user acceptance and reducing fuel consumption while driving.

1 Introduction

Global warming and rising oil prices have led to a state of increased awareness for ecological and economical issues in use of cars. Despite the fact that a lot of effort has been taken to decrease fuel consumption on a technical level of automobiles, few measures are currently promoting a less energy consuming way of driving. Most drivers do not even know how to drive efficiently or have wrong knowledge about this issue. Dorrer [1] states that the cars fuel consumption can vary up to 50 % depending on the driving behavior.

Networked automobiles provide new opportunities for applications motivating a fuel efficient driving behavior. This work focuses on influencing driving behavior of car-users in real-time by using a persuasive community application in terms of location based fuel consumption competitions on mobile devices. Due to the fact that the development cycle of automobiles and in-car systems is comparatively long, mobile devices offer the opportunity to be quickly responsive to upcoming trends like efficient driving.

Currently persuasive in-car interfaces can in general be divided into two categories. On the one side several car manufacturers and researchers are trying to persuade car users to drive efficiently in terms of gear shifting recommendations, ambient lights for an efficient acceleration or haptic gas pedals [5]. All these interfaces are aiming at the stabilizer's level of the driving task in real-time. On the other hand interfaces for giving feedback about the driver's historic fuel consumption are trying to influence the driving behavior on the operator and navigator level. This is often combined with community features for comparing one's energy consumption with other drivers without any feedback during the driving task itself [5]. Our concept of location based challenges allows the combination of the idea of historic competitive systems and real-time feedback.

2 System Design

One key aspect of our concept is the comparison of fuel consumption among drivers in real-time in order to create a game-like situation. By doing this social comparison [2] we assume a high motivation to change one's driving behavior [3].

The game consists of several route sections (challenges), which are placed along the driver's intended route. Consuming less fuel than other competitors on the same track is the main goal of these challenges. Each challenge has a start and an end point (location based). Between these points a real-time comparison with other drivers on this route section is supported by the user interface of the developed prototype.

Since most mobile devices only offer limited screen estate, the screen layout had to be as clear as possible. As the driver's primary task, controlling his car has to be taken into consideration. To achieve this we set focus on the following 3 principles, derived from the Persuasive System Design principles [2]:

1. Adapt the UI to the driving situation
2. Present important information in an understandable way [4]
3. The driver should be notified as clear, but as unobtrusive as possible

When standing still, information needed while driving (e.g. average consumption per kilometer) is hidden and additional information, i.e. name of the challenge, number of competitors and a monetary representation of the needed fuel is displayed. While driving, the mobile phones keyboard interaction is deactivated and the driving specific information is displayed. In this paper we will focus on the displays during the challenge condition which are explained below.

In our prototype challenges on a track are automatically joined. When joining a challenge, the GUI switches to challenge mode, showing relevant real-time graphs enabling social comparison in the current run (Fig. 1). The *available* fuel for the current challenge run is represented by a bubble of gas, which is computed from the average community consumption (2*avg). The green, blue and red horizontal lines indicate the best, average and worst consumption of all former participants. The progress of the challenge is visualized by a blue circle surrounding the bubble. The ring expands from the top towards the bottom as the car moves. When traversing the finishing point, the ring fully encases the gas bubble. The current fuel consumption is displayed using a gauge on the right side of the screen (Fig. 1), similar to a consumption gauge in a car's dashboard.

Notifications (e.g. challenge start, finish and ranking) are presented in a pop up full-screen using a big font and are accompanied by acoustic feedback and an icon. After several seconds, the notification automatically disappears and the gas bubble containing all relevant challenge information appears.

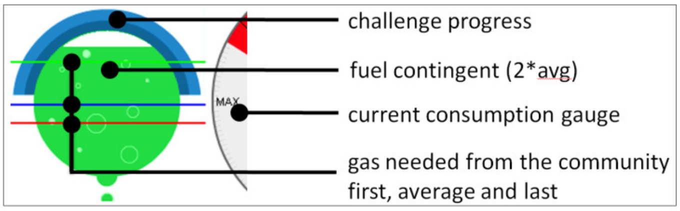

Fig. 1. User Interface on the mobile device.

The prototype was implemented in JAVA Micro Edition. The required car data is communicated via Bluetooth to the mobile phone. Therefore all JAVA and Bluetooth enabled devices can be used.

3 Explorative User Study

For a preliminary evaluation, a small explorative field study was conducted. Due to such external factors as differing traffic or weather, conditions for participants are not equal and results throughout are not comparable amongst all participants. Although for a first impression a field study appeared to be most appropriate. Due to the fact that participants are in a competitive situation we assume that this results in a higher motivation for efficient driving and higher attention during the driving task. Consequently a more anticipatory driving behavior is assumed. This is measured by the average fuel consumption and confirmed by investigators observations.

All participants had to drive on a medium frequented road. The distance was 5.2 km and six traffic lights had to be crossed. The speed limit was mainly 60 km/h and the road consists out of two lanes. On this route two location based challenges were located. The experimental vehicle was a BMW 530i where the mobile device was mounted in the center stack.

The objective dependent variable was the consumption per 100 km (avgCon). The independent variables were the challenge system and the baseline condition.

In the beginning all volunteers had to drive a baseline run without our system, but aware of the fact that this study investigates the fuel efficiency during driving. After this, the system was explained until the participants felt secure. Then the locations of the two challenges were shown on a map. Challenge number one (LoR1) comprises a distance of 1.2 km and challenge number two (LoR2) a distance of 1.1 km. Afterwards the challenge condition was driven. At the end a questionnaire was filled out by all participants judging user acceptance.

We had five attendees (2 females, 3 males) who were familiar with the route to drive and were experienced drivers. The average age was 33 years.

The results of LoR1 in terms of average consumption per 100 kilometer were unambiguous. In average this section was driven with 1,4 l/100 km less under the challenge condition (ø 7,6 l/100km) than under the baseline condition (ø 6,2 l/100km). In contrast the results of LoR2 are not as clear. Two attendees drove this section with less, one with the same consumption and two with more fuel consumption under the challenge condition. In average the challenge condition was driven with 0.4 l/100km less fuel consumption (challenge = 5.6 l/100km, baseline = 6.0 l/100km).

In the questionnaire (n=5) the participants subjectively noted on a 1 to 7 point Likert scale (not at all / totally) that the challenge was system was understandable (6.1), supportive (5.6), assisting/motivating an efficient driving behavior (5.6 / 6.2), fun (6.4), distracting (5.4). All volunteers stated that the current consumption gauge was not recognized at all and that the gas bubble including the ranking and challenge progress was the most helpful display element.

4 Conclusion and Future Work

The presented system seems to motivate drivers to adopt a more fuel efficient driving behavior. At the same time the user study allows the assumption that the usual boring and annoying character of an ecological driving style is overcome by our prototype. Car users are able to explore their driving performance in real-time and compare their performance to a group of other users previously driving on the same route. According to our explorative user study we assume that drivers are much more motivated to drive efficiently.

The evaluation of our rudimental prototype confirms that our concept of location based fuel consumption challenges is a promising approach to motivate and persuade drivers toward a more ecological driving behavior. According to the participants statements we suppose that this kind of system can be even more obtrusive and has to be less distracting for the application in automotive environments. One thrilling question for the future is the integration and adaptation of our approach into the vehicle environment under consideration of all in-car displays.

5 References

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