Towards an Application Platform that Allows Access to Sensors in the Car

Bastian Pfleging
Pervasive Computing and User Interface Engineering Group
University of Duisburg-Essen
Schützenbahn 70
45117 Essen, Germany
bastian.pfleging@uni-due.de

Marvin Steinberg
Pervasive Computing and User Interface Engineering Group
University of Duisburg-Essen
Schützenbahn 70
45117 Essen, Germany
marvin.steinberg@stud.uni-due.de

Alireza Sahami Shirazi
Pervasive Computing and User Interface Engineering Group
University of Duisburg-Essen
Schützenbahn 70
45117 Essen, Germany
alireza.sahami@uni-due.de

Albrecht Schmidt
VIS, University of Stuttgart
Universitätsstraße 38
70569 Stuttgart, Germany
albrecht.schmidt@acm.org

CHI 2011, May 7–12, 2011, Vancouver, BC, Canada.
ACM 978-1-4503-0268-5/11/05.

Abstract
Modern cars include a multitude of sensors that can monitor how people interact with the car and can acquire information about the status and surrounding of the car. In two scenarios we explain briefly why such information is valuable and how potential implicit and explicit crowdsourcing services can work with this data. We then discuss what types of information are available and how collecting and sharing them creates a new platform for interactive in-car applications. One class of information is related to users' interaction with the car like steering the car or using the navigation application. A further class of information is multimedia data generated by in-car cameras (e.g., night vision). We implemented a platform to make it easy for developers to acquire and share such data. In the final part of the paper we discuss possible application scenarios.

Keywords
Automotive user interfaces, crowdsourcing, sensor based interaction

ACM Classification Keywords
H5.2 User Interfaces (Input devices and strategies)
H5.m. Information interfaces and presentation (Miscellaneous).

Introduction
In modern vehicles several bus systems connect components in the car in order to locally communicate a

large amount of data. The information includes driving parameters, interaction events, sensor information from the car and the environment, as well as actuators controlled. Currently, this information is used locally in the car to enable assistive functions like electronic stability control to support the driver. The amount of data is large and hence this data is typically neither stored over a long period nor is it available outside of the car.

In this paper we look at what value such information can provide for advancing user interfaces in the car and for creating novel interactive applications and services if we store and share this information. These services might for example support the driver, provide meaningful information to passengers, support communities, and offer information to other drivers.

The information collected and shared comes from the driver interacting with the car and by this proxy with the environment. We consider the interaction by the drivers with regard to data generation as implicit interaction [1]. The information is generated implicitly, as drivers have as their main task the interaction with the vehicle but create inevitable information by their interactions. For sharing the information within a community we consider two modes – explicit and implicit sharing. Additionally we can consider these types of data collection as *explicit and implicit crowdsourcing*.

Scenario 1: Implicit Crowdsourcing: Monitoring Roads
A local community is interested in the quality of its roads. This task is crowdsourced to voluntary drivers in the community. They allow their car to continuously provide anonymized data (speed, vibration) that allows to reason about the road to the platform. Once the crowdsourcing request is accepted, the data gathering and contribution are made without active user involvement (implicit crowdsourcing). With the geo-referenced vibration and speed data the community can chart the quality of the pavement and spot dangerous holes. In contrast to sending out inspectors this is much cheaper and provides more timely and high quality information.

Scenario 2: Explicit Crowdsourcing: Road Maintenance
Similarly the community may want to know where drivers think maintenance is required. This task is crowd–sourced explicitly. Drivers can take action to provide data if they see something where they think repair is required. Their message consists of a short audio report as well as data from cameras and sensors that monitor the car's surrounding. If the driver sees a rock that has fallen dangerously close to the side of the road she initiates the request by calling a specific phone number. When the call is established the last minute of data that provides information about the surrounding of the car and the message are sent to the platform. The responsible person gets the audio message, sees the rock on the stream of the rear-view camera and sends somebody off to clear up the road.

Background and Related Work

Harvesting wisdom of the crowd, referred to as crowdsourcing, has been investigated in various domains and gained popularity over recent years. Generally, the harvesting can be subdivided into an implicit and an explicit way. While in the explicit case users intentionally generate the content, in implicit solutions the content is generated implicitly based on the user's actions. The advantage of implicitly generated content is that there is no extra effort for the user to contribute this content.

On the Web there are projects whose success is based on contributions of a huge number of users (e.g., Wiki–pedia). Also various researchers have investigated different features of crowdsouring systems (e.g., [2]). The ubiquity of interactive mobile devices leads to the use of mobile phones for the crowdsourcing approach. In [3] a mobile crowdsourcing approach is shown where users use their mobile to solve location-based tasks. Navigation apps like Waze[1] or Google Maps Navigation[2] implicitly collect coarse location data from mobile phones and use crowdsourcing to accumulate traffic data to enhance navigation services. On the other hand, as previously mentioned, vehicles are enhanced with various sensors, which provide different data about the status of the vehicle. CarTel [4] is a mobile sensor computing system designed to gather, process, and visualize data from sensors of mobile units like cars.

In-Vehicle Context Information Gathering and In-Car Crowdsourcing

The data that can be gathered from the car and used in implicit and explicit crowdsourcing systems is mainly based on the sensor information acquired by the car. It can be grouped into different categories as follows:

Interaction related information

As modern cars monitor the usage of primary, secondary and tertiary controls electronically nearly all user interaction in the car can be monitored.

Examples of interaction with primary controls are turning the steering wheel or pressing a pedal. Information about these activities is available at a raw level (e.g., steering angle) but can be used to calculate higher-level events. Monitoring primary controls provides the basic data about a driver's behavior and allows deducing activity data. If this information is geo-referenced and compared to other drivers (un-) typical behavior can be detected. This comparison of average and observed behavior with regard to using primary controls is a rich source for understanding user behavior and brings us a step closer to reason about intentions of interactions.

Raw car-related information

A further set of information is only indirectly linked to the driver's interaction with the car. We divide it into the following categories:

- *Primary vehicle data* includes for example data about current speed, or slip on the surface. Comparing and sharing this data allows to get more insight on how interactions of the driver impact specific parameters.
- *Extended sensor data* comprises the output of the different car sensors which go beyond the primary data and which is already in common use. Examples are location, temperature, tire pressure, and motor data.
- *Infotainment data* is a rich source of data monitoring explicit interaction with specific in-car applications. The navigation application provides details about the current origin/destination and driving preferences. Beyond this explicitly provided data there is also implicit data, e.g., if the user evades from the suggested route we may assume he made an error or knows the area.
- Detecting and sharing data about *communication* partners, the chosen communication modalities, and the duration of calls carries is a valuable information that may help to improve future communication applications and UIs in the car.

Multimedia Capture and Environment Information

Top end cars have already now a whole set of mechanism like cameras to capture their environment aboard, and as technology advances we expect that these technologies become widely adapted in all types of cars.

[1] http://world.waze.com/
[2] http://www.google.com/mobile/navigation/

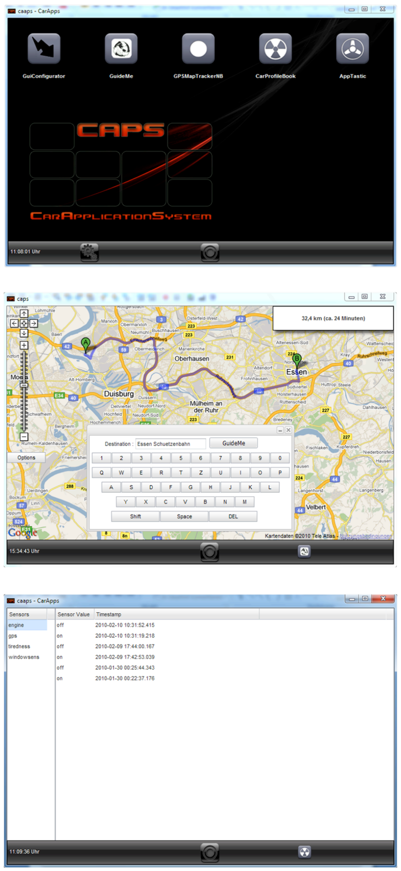

Figure 1. Screenshots of the sample applications:
a) The home screen of the application gives an overview of the available applications.
b) A navigation application that makes use of the car's GPS data.
c) The CarProfileBook app allows browsing all available sensor data.

Additionally to the data about the car and its passengers, also data about the closer environment of the car can be gathered and published. Thus, information about, e.g., the road/lane used, other cars around, or weather information could be geo-tagged and shared.

Platform and Implementation

We have created a platform called capsFramework based on a JBoss application server and a PostgresSQL database that provides an API to access sensor information and context. The actual sensors are connected over an UDP-based network interface.

Our first PC-based prototype uses simulated sensors. In order to make the platform fit to a car only a service that translates real sensor events (e.g., CAN messages) into UDP datagrams is needed. Apps built on top of the platform are independent of the specific car as they only use the platform API to access the sensors. The current prototype is not yet deployed in a car.

In order to investigate what interactive applications can be created in such a system we have build applications that address specific aspects of such a system. Some examples are shown in figure 1.

Application Scenarios

In our research we assessed which new or typical application areas will be enabled by such a platform. In the following we share some of the ideas that were generated. Many of these domains correlate with challenges discussed in [5]. If the data from a multitude of cars becomes available in real-time, this could lead to means for understanding and improving the *economic behavior* of a car, *predicting failure,* and to *proactive maintenance*. Similarly, the data could also be interesting for insurances as it allows a more *fine-grained risk assessment of drivers and cars*. The *road safety* could be increased by using crowdsourced information and *traffic planning* could be improved. Using a detailed fuel consumption log one could even establish a taxation that allows a direct *billing by environmental impact*.

Conclusion and Future Work

There seems to be a great potential for community applications making use of data from a larger set of cars and drivers available through a car-independent platform and APIs. We argue that such a new resource can create new interactive applications in this context and can offer new opportunities for implicit and explicit crowdsourcing in the context of cars.

We work towards extending the framework to work with the full set of sensors and to port the platform to a real car. Within a real car environment one major issue is to connect the software in a way to get full access to real in-car bus systems. Finally we would like to explore more different types of applications.

References

[1] Schmidt, A. Implicit Human Computer Interaction Through Context**,** *Personal Technologies*, vol. 4, no. 2&3 (2000), 191-199.

[2] DiPalantino, D., Vojnovic, M. Crowdsourcing and allpay auctions. Proc. of Electronic commerce, 2009

[3] Alt, F., Sahami, A., Schmidt, A., Kramer, U., Nawaz, Z. Location-based crowdsourcing: extending crowdsourcing to the real world. Proc. NordiCHI '10

[4] Hull, B., Bychkovsky, V., Zhang, Y., Chen, K., Goraczko, M., Miu, A., Shih, E., Balakrishnan, H., Madden, S. CarTel: a distributed mobile sensor computing system (2006):pp. 125–138f.

[5] Schmidt, A., Spiessl, W., Kern, D. Driving Automotive User Interface Research. IEEE Pervasive Computing 9, 1 (2010), 85-88.