DriveAssist – A V2X-Based Driver Assistance System for Android

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Abstract

In this paper, we introduce the Android-based driver assistance system *DriveAssist*. The application allows the visualization of traffic information that originates from Vehicle-to-X (V2X) communication services as well as from central traffic services (CTSs) on the user's smartphone. Besides giving the driver an overview of the traffic around her/him on a map view, *DriveAssist* can also run in the background and trigger warning messages for certain traffic incidents. The system design allows for augmenting any vehicle with a sophisticated audio-visual information system for V2X data and information, and thereby complements the vehicle's on-board driver assistance systems at competitive costs.

1 Introduction

Vehicle-to-X (V2X) communication (Popescu-Zeletin et al. 2010) is a promising technology that has the potential to improve the safety of everyday road travel (Röckl et al. 2008). A 2010 study performed by the U.S. National Highway Traffic Safety Administration (NHTSA) concluded that Vehicle-to-X systems could potentially address 81% of all-vehicle target crashes (Najm et al. 2010). Although it is clear that an efficient visualization for such V2X systems' data is crucial for the drivers, research is still mainly focusing on system and technology aspects, such as radio communication, GeoNetworking, or information generation. With our Android-based driver assistance system *DriveAssist*, we contribute design and implementation concepts concerning the presentation of traffic information.

The availability of powerful mobile devices, such as smartphones and tablet personal computers, makes those personal portable devices (PPDs) considerable alternatives to in-vehicle integrated systems (Diewald et al. 2011). Especially in mid-sized cars or compact cars, which often have no head unit at all, the user's PPD can be used for adding functionality in the automotive domain. Also today's premium cars offer the possibility of coupling a PPD to the in-vehicle system. In our approach, the mobile device is used to run the application as well as for providing the HMI. But it is also thinkable, that the PPD uses the vehicle's built-in head unit as display and input interface (Bose et al. 2010).

The paper is structured as follow: In the subsequent section, we give an overview on similar approaches and situate our approach in this context. We then present the setup of our system and introduce our Android-based driver assistance system *DriveAssist*. We conclude with a summary of our findings and implications on future work.

2 Related Work

Since today's smartphones and tablet PCs are equipped with a range of modern and highly accurate sensors, they can also be used for analyzing driving related scenarios. Mednis et al. developed a system that allows the detection of potholes using a mobile device's built-in accelerometer (Mednis et al. 2011). Mednis's Android application achieved a true positive rate of 90% in real world usage. The driving context can also be derived directly from the vehicle's on-board diagnostics system. For example, Zaldivar et al. used the On Board Diagnostics II (OBD-II) interface for accessing safety relevant data, such as G-forces and airbag states (Zaldivar et al. 2011). By combining this data with measurements from the mobile device's sensors, a high detection rate of serious accidents could be reached.

The combination of a mobile device with a V2X communication unit has already been treated by several researchers. Grimm provides a high level discussion of a mobile device communicating with a Vehicle-to-X gateway (Grimm 2011). In his approach, a smartphone was used as platform for developing new services without the need of changing the vehicle's architecture. Diewald et al. discuss a similar setup with a more detailed look on the component split (Diewald et al. 2012). Their approach is focused on rapid development of new applications. They further state that the combination of a V2X on-board unit with a mobile device "seems to provide a viable solution for market introduction of V2X systems."

3 System Setup

Our system consists of two components:

- A vehicle-integrated V2X communication unit (on-board unit, OBU), for example, supporting ITS G5 or 802.11p.
- One or multiple personal portable devices, such as smartphones or tablet PCs.

The slowly evolving standardized V2X communication unit can be directly integrated in the vehicle's system. This unit can also be retrofitted in any existing vehicle with only little efforts. Since V2X communication is based on slowly changing standards, it is not very likely that the V2X unit is outdated within a typical car lifespan of 9 years[1]. The usage of a personal portable device as data processing unit and HMI has multiple benefits (Diewald et al. 2011). For example, in safety-critical situations it is very beneficial when the driver is accustomed to the HMI. This is especially of interest for car sharing scenarios. Also, whenever a user buys a new PPD with more sensors, higher processing power and better display, it is like a car hardware upgrade that enables new applications.

In our setup, the on-board unit acts as V2X gateway that handles the radio communication, the GeoNetworking as well as the encoding and decoding of the V2X messages. Connectivity between the components is based on the Internet Protocol (IP) and can be established via WLAN, Bluetooth, or USB CDC. The OBU is further connected directly to an accurate in-vehicle GPS receiver and automatically creates the default beacons and V2X messages for the vehicle. The mobile device also gets copies of the messages from the ego vehicle and can use the (in most cases more accurate) GPS position from the V2X unit for its calculations.

4 The Android-based Driver Assistance System *DriveAssist*

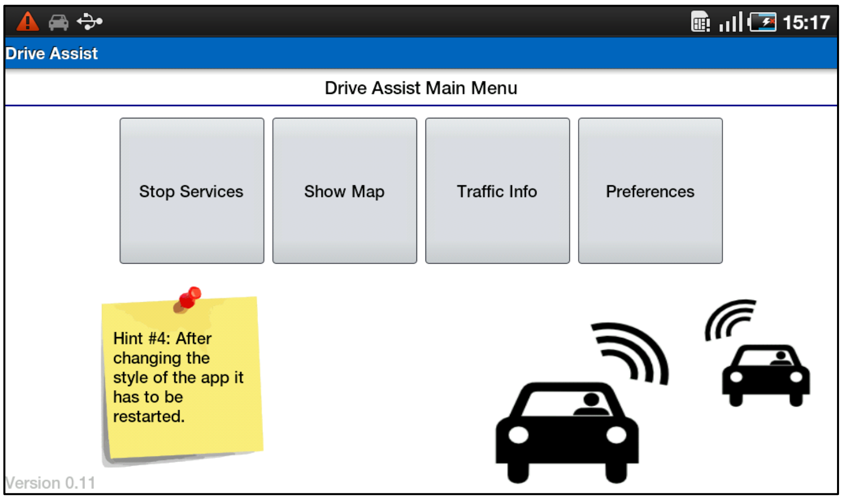

Figure 1: DriveAssist's main menu. The four big buttons in the top row are optimized for in-vehicle usage and allow controlling the central parts of the application. The yellow hint (bottom left) shows short pieces of usage information, when it is enabled in the preferences. The prototype runs on a 7 inch Samsung Galaxy Tab with Android 2.3.7.

[1] http://www.buyingadvice.com/featured-car-articles/vehicle-lifespan-survey/, last visited June 27, 2012.

DriveAssist is our first prototype of a driver assistance system for Android. Its main feature is the combination of data from multiple sources, including V2X communication. *DriveAssist*'s main menu is depicted in Fig. 1. Since the application is designed for the usage in vehicles, it has a very clear structure and large control elements. The four big buttons of the main menu give access to the central parts of the application. They allow:

- Starting and stopping the background services.
- Showing a map view for visualizing nearby traffic events.
- Displaying an overview of all available traffic information in a large sorted and filterable table.
- Changing the application's preferences, such as the radius of interest or the theme.

In the following subsections, we introduce the concept and the most important components of our system.

4.1 Data Sources and Message Handling

The information from V2X communication is currently derived from Cooperative Awareness Messages (CAMs, ETSI TS 102 637-2, 2011) and Decentralized Environmental Notification Messages (DENMs, ETSI TS 102 637-3, 2011). So far, the following Day-1 use-cases are supported (Popescu-Zeletin et al. 2010):

- Approaching Emergency Vehicle Warning (AEVW, CAM)
- Electronic Emergency Brake Lights (EEBL, DENM)
- Stationary Vehicle Warning / Post-Crash Warning (PCW, DENM)
- Traffic Jam Ahead Warning (TJAW, DENM)
- Working Area Warning (WAW, DENM)
- Hazardous Location Notification (HLN, DENM)

Additionally to the V2X information, *DriveAssist* can also query central traffic services (CTSs) using the PPD's mobile data connection. These free or paid services are normally provided by service providers that collect and aggregate data from different sources. Common sources are the police, road maintainers, private persons, or automobile clubs. For measuring the traffic flow, automated sources such as sensors (light barriers, induction loops), floating phone data (FPD), or floating car data (FCD) are the state-of-the art. In our research prototype, we aggregate data from TomTom's HD Traffic[2] that is accessible via the Internet.

When there are multiple traffic events nearby, prioritization is applied: generally, approaching, moving traffic events, such as moving emergency vehicles or a sharp breaking vehicle, have higher priority than static events. Static events are sorted by their distance to the vehicle.

[2] http://www.tomtom.com/livetraffic/, last visited June 19, 2012

4.2 Presentation of Traffic Events

In safety-critical situations, it is important that the driver can instantly recognize what type of traffic incident is reported. For that reason, common standardized German traffic signs (BASt, VzKat 2009) have been used for indicating the traffic incidents' types. In case there was no appropriate official sign, meaningful pictograms following the design principles of the official signs have been created. All warnings are presented in a red triangle (see Fig. 2 and Fig. 3) that symbolizes "attention". Besides the visual warning, text-to-speech (TTS) can be enabled in the preferences. The TTS informs about new events and can repeatedly warn the user when she/he approaches an incident. The distances and repetition interval can be defined in the preferences.

4.3 Map View

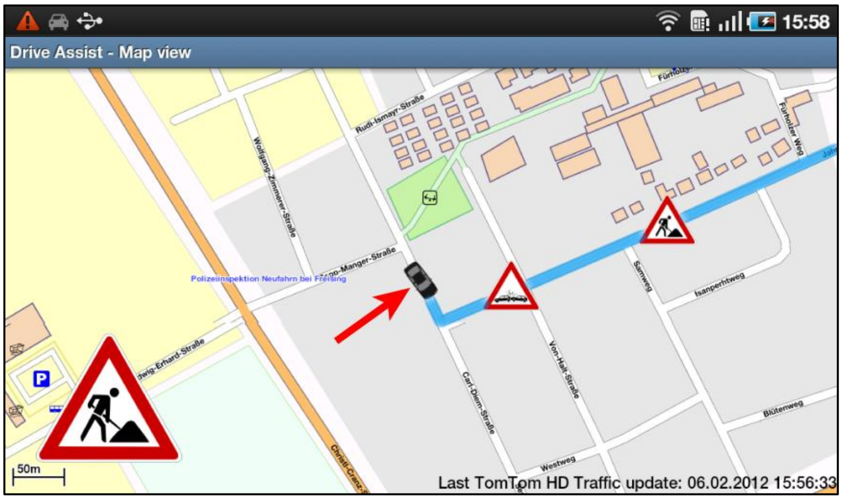

Figure 2: DriveAssist's map view. The driver's vehicle is represented by the black car in the center (marked by the arrow). The large traffic sign in the bottom left corner indicates the type of a newly received traffic event. The small traffic signs indicate the position as well as the type of the traffic event on the map. The map view is automatically brought on top if traffic data relevant to the current driving context is available

For providing an overview to the driver and the other vehicle passengers, a map view can be started. In Fig. 2, a typical situation is depicted. The car is approaching a stationary vehicle, for example, after a car accident. Further down the cross street, a working area warning (WAW) is displayed. By zooming out, all received traffic events can be seen. For CTSs this can cover an area of several 100 square kilometers. By tapping on an icon, additional information is displayed. This information contains, among other things, the source of the information, a more precise description of the event, and, when available, also the length and the time-loss due to the event. For acoustic notifications about new nearby incidents, a circle of interest around the car can be defined. New events are also indicated by a larger version of the warning symbol in the lower left corner of the screen. Besides the map view, it is also possible to get a list of all nearby incidents.

4.4 Passive Warning Screen

An important part of *DriveAssist* is the background warning service that can trigger a warning screen. The service allows starting and displaying a warning, although another application, such as a navigation application or the phone interface, is currently shown. Similar to the map view, the user can also specify a circle of interest in the preferences, when she/he wants to be informed about nearby incidents. The mentioned prioritization algorithm ensures that the user is always warned first of the incident that could affect her/him next.

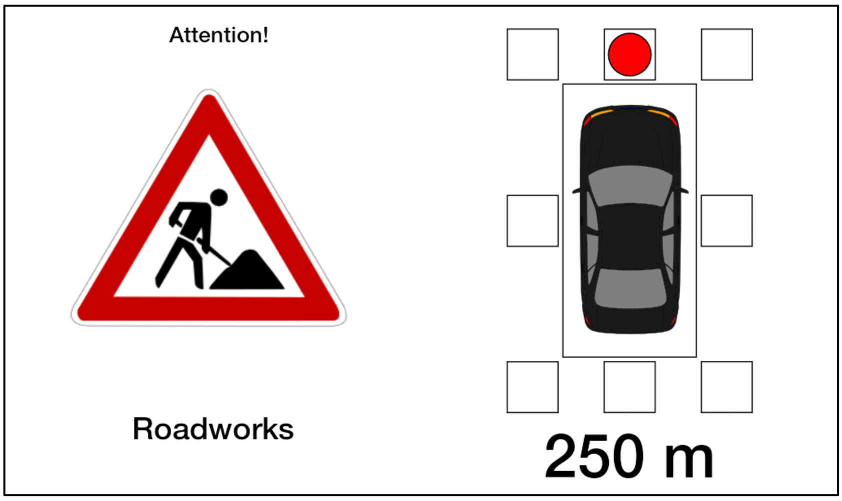

Figure 3: DriveAssist's warning screen. The warning screen shows the type of the detected traffic incident through well-known standardized traffic symbols. The direction of the event relative to the car is indicated by the red dot (here: above the ego vehicle). The visual output is accompanied by a text-to-speech generated audio warning.

Fig. 3 shows a working area warning (WAW). The construction site is 250 meters ahead of the vehicle. Besides the symbolic presentation, there is also a textual description ("Roadworks") on the screen. The red dot indicates the direction of the incident relative to the car's long axis. The eight sectors scale allows the driver a fast estimation where the incident is. The distance to the event is rounded down to multiple of 50 meters (configurable in the preferences) and updated regularly. Whenever the distance to the incident falls below a definable distance that does not anymore allow a correct estimation of the direction in which the incident is located, the dot is replaced by a red rectangle around the vehicle. Together with a TTS output, this shall inform the user that the incident is nearby and can be anywhere around the car. An example warning screen with a traffic jam ahead warning (TJAW) is depicted in Fig. 4.

When the vehicle has passed the incident, the warning screen is closed automatically, or when another incident is nearby, another warning is displayed. A minimum display time of 5 seconds for each warning screen ensures that the user can easily follow the messages, even though a warning with higher priority has to be shown.

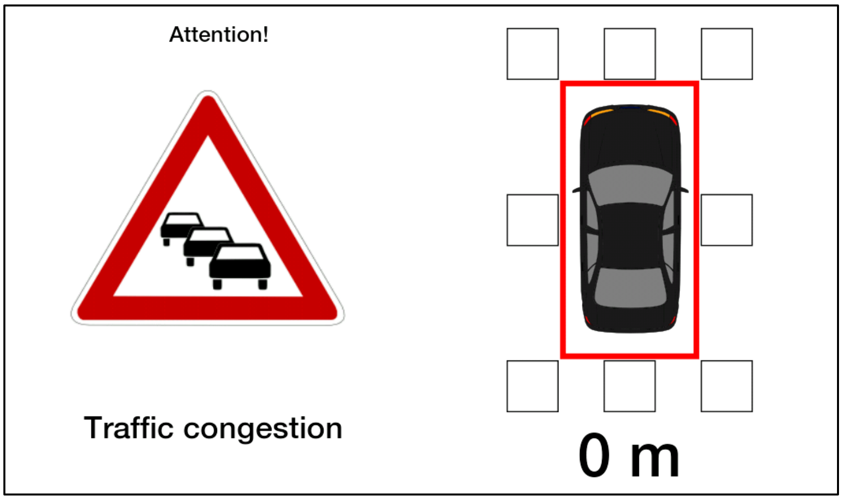

Figure 4: When the traffic event is nearby (e.g. less than 15 meters away), the GPS accuracy does not allow indicating the precise position of the event. For that reason, the red border around the car shall symbolize the user that the event can be anywhere around the car.

The warning message is always displayed full-screen and does not need any kind of interaction. Depending on the PPD's Android version, *DriveAssist* can also run when the screen is turned off and can turn the screen back on when a warning should be displayed.

5 Conclusion and Outlook

We have shown our first prototypic implementation of an Android-based driver assistance system. Our solution is able to combine traffic information from different sources and offers several modes for informing and assisting the driver and vehicle passengers. Since the solution is based on a V2X unit that can be retrofitted in any vehicle, and mass-market mobile devices, we think that this system could be an affordable solution for the broad market introduction of V2X. The combination of data from V2X and CTSs further allows for a good operability from the beginning on, even when there are only a few vehicles equipped with V2X communication.

Besides improving the safety of everyday road travel, the gathered information could also be used for improving the driving efficiency and comfort. For example, the route could be adapted to the current traffic situation, or the system could suggest changing to public transportation by evaluating the timetables of nearby stations via central traffic services. For that reason, we will integrate navigation functionality in the next version of *DriveAssist*. We will further conduct a user study for evaluating and enhancing our solution in the near future.

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