CODAR VIEWER - A SITUATION-AWARE DRIVER ASSISTANCE SYSTEM

Matthias Kranz, Andreas Franz, Matthias Röckl, Andreas Lehner, Thomas Strang
{matthias.kranz, andreas.franz, matthias.roeckl, andreas.lehner, thomas.strang}@dlr.de[1]

Abstract
The CODAR system is a simulation and visualization toolbox for vehicle-to-vehicle communication. In this paper, we introduce the visualization component of CODAR Viewer as context information display. It visualizes communication, creates awareness and provides situation information. Visualized vehicle-to-x communication data provides additional information, increasing safety and allowing more informed driving decisions if adequately presented to the driver with respect to the current traffic situation.

1. Introduction

Modern vehicles have a significant number of intra-vehicle communication systems and busses and hundreds of sensors connected, delivering information at high data rates. The sensor density in modern cars is comparatively high as in pervasive computing environments. Interconnecting sensor-equipped enables novel types of applications. The idea of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication is to collaboratively share a subset of this information to increase road safety, efficiency and comfort.
In this demo, we present two aspects of the *CODAR* (***C***ooperative ***O***bject ***D***etection ***A***nd ***R***anging) system, a toolkit combining simulation, visualization and algorithm toolbox for vehicle-to-x (V2X) communication systems. The *CODAR* system allows the developer of V2X applications to fusion, test and simulate communication, to test algorithms, and to visualize traffic scenarios. The aspects demonstrated in this paper are the global network visualizer view and a driver human-machine interface (HMI) component view.
Many applications of V2X communication work autonomously on system level such as pre-crash sensing (driving assistance) or forward information to the driver in critical situations (driver assistance) e.g. warning messages of a broken down vehicle. The *CODAR Viewer* component, as driver assistance system, is an additional source of information for the driver. The situation and context interface enables the driver to build up an increased situation awareness and consequently a better traffic overview.

2. Related Work

V2X communication visualization is dynamic, mobile, and ad-hoc geocoding and inter-relating of information. It connects time information and geographic location with physical information such as the vehicle's internal and external state, the driver's awareness or environmental features such as temperature or road conditions.

In contrast to so-called Fleet Management Systems (FMS) such as FBOWEB for planes [2] or Digital Seas for ships [4], the *CODAR* bases on V2X communication, currently under standardization in the Car-to-Car Communication Consortium. FMS do only transmit vehicle data to a central instance. Applications are fleet management (e.g. selecting the closest delivery truck for the pickup), they do not share this information with other equipped vehicles or outside the business scope. The V2X-based *CODAR* system does communicate directly with other vehicles, based on geographic position or the vehicle's

[1]German Aerospace Center (DLR), Institute of Communications and Navigation P.O. Box 1116, D-82230 Wessling, Germany

navigation target. It does not require a central instance and information is shared directly among the vehicles. This novel context- and situation awareness for drivers is enabled by the *CODAR Viewer*.

Scholl et al. [1] geocode static sensor nodes as web services with low update rates using Google Map as display engine. The sensor information is collected in local cells and made available by network-to-network bridges on the internet as web service. The final application provides the user an absolute global information view, aggregating all present information. The nodes in the *CODAR* system are much more dynamic and mobile and use all available in-car sensing systems and are not a limited to acceleration sensor etc., but can use e.g. information from the CAN bus of a vehicle, such as steering angles, pedal positions, or VSC activity.

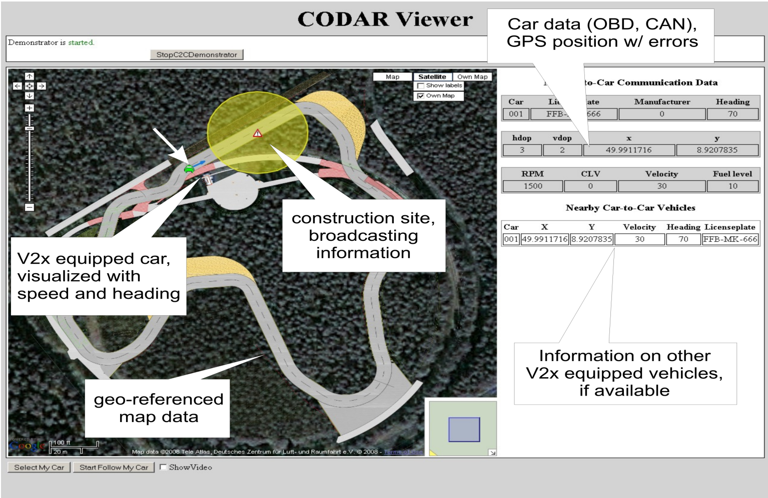
Compared to personal navigation systems which do also track one's own position and are able to display information about near-by items (point-of-interest notification), the data displayed on the *CODAR Viewer* is updated more dynamically by other traffic participants and road-side units. This is not limited to traffic jam notifications as it is currently with the latest navigation units. The *CODAR Viewer* shows real-time situation information. While dynamic information could be added using e.g. a point-to-point 3G mobile internet connection, the V2X data is originating from a dedicated V2X communication infrastructure using unicasts, broadcasts and geocasts.

3. CODAR Viewer

The *CODAR Viewer* Traffic Management Center (TMC) view is depicted in Fig. 1 (a). The system collects information from so-called road-side units (RSUs) which are treated as static vehicles. The RSU can, but are not required to have, a static internet connection and can bridge data from the V2X network to central services. They could be integrated in toll collect systems and allow TMCs a much more up to date traffic information. Additionally, warnings e.g. of low road friction due to environmental conditions, sensed by a vehicle's vehicle stability control system, can be mediated and additionally shared in a cooperative way. The left part of Fig. 1 (a), without the textual information on the right side, is displayed locally to the driver via an HMI, such as the vehicle's navigation screen. The advantages here are an increased situation awareness and context information, if presented to the driver in a meaningful way. The data is sensed locally in two senses: in the own car, and, by other geographically co-located car. This allows the driver to see around a curve or behind a hill top. This is currently not possible, even with night vision systems or radar. Information about safety critical issues are exchanged locally. This has significant advantages to radio announcements and radio featured Traffic Message Channel information. Both are broadcasted with a much lesser frequency (e.g. every 15 minutes in case of the radio) and with a lower data rates (e.g. 100bits/s with Traffic Message Channel). In both cases, it is usual to miss announcements. The V2X based *CODAR Viewer* system exchanges data at high rates, usually 4 times per second and allows a higher bandwidth from the underlying V2X system. The *CODAR Viewer* also is not restricted to the GMaps underlying the applications. Own geo-referenced aerial images, satellite images and other types of digital maps (see Fig. 1 (a)) are used.

The *CODAR Viewer* can be used in real-time mode as discussed above, but also as simulator-only front end or in combination. This allows to evaluate different human-machine interactions in different scenarios with real and virtual vehicles.

The *CODAR Viewer* as radar-like visualizer for V2X communication conveys information to the driver and provides assistance in situations that are not supported by other technologies. While radar or night vision can improve the sight of the driver, they cannot 'see' around the curve or behind a hill top or detect a vehicle quickly approaching a crossing in the city. **Visualized** V2X communication complements existing technologies in a great variety of situations.



(a) *CODAR Viewer* - Traffic Management Center View

(b) In-vehicle Sensing and Communication Unit

Figure 1. The network view (left) allows a TMC to view the current traffic situation. Relevant vehicle information are displayed in the right column. The in-vehicle HMI currently features only the map view without additional textual information. Own map data (satellite image and drawing) are overlayed with traffic information. The vehicle (white arrow) in this situation approaches a road construction site and is warned by a RSU in time before entering the actual area of road work. Awareness of the situation is increased, the vehicle's speed and the driver's alertness can be adopted. A V2X equipped car is displayed on the map with their current position, heading (arrow direction) and speed (arrow length). The right image shows the integrated in-vehicle unit with its debug display.

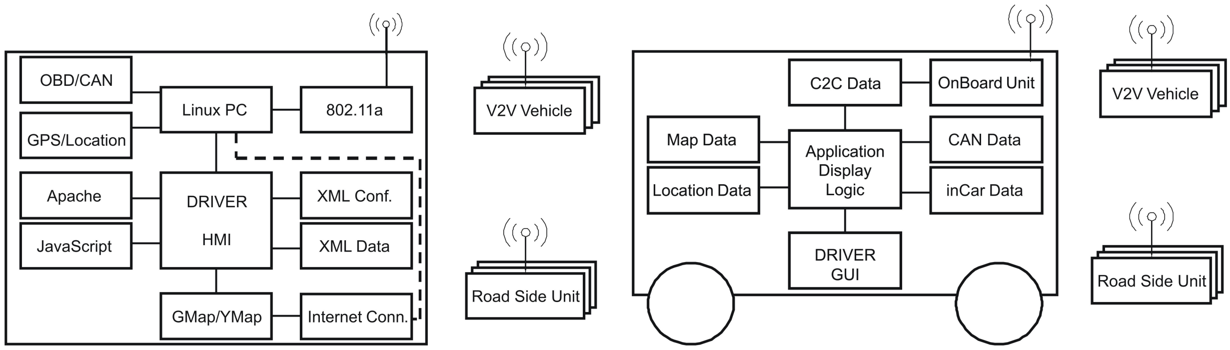
The *CODAR Viewer* supports the driver in several ways. It creates **individual awareness**. The driver knows more about **his or her** imminent situation and can make more informed decisions. The application supports **cooperative awareness**. The driver now has information about the context of **other road users**. This supports a better understanding, e.g. why there is a traffic jam and that it only goes on for half a mile or that it does not make sense to overtake a truck as there is another one close which cannot be seen from the vehicle's current position.

Due to the ability of visualizing other cars with their position, speed and heading, and consequently their drivers as well as the own vehicle in their *CODAR Viewer*, privacy concerns might arise. This is currently an open research topic. It is envisioned that these issues will be addressed by the underlying communication infrastructure. The publicly visible vehicle ID for example can be changed by the V2X system on demand to prevent tracking, e.g. as part of a Virtual ID (VID) system. As Krumm et al. [3] proved that GPS traces can actually reveal much more information about an individual than the mere location points, even if the origin is artificially obscured.

4. Demo and System Description

The proposed demo will feature the TMC view (Fig. 1 (a)) on a portable display unit. Data of real vehicles from our test site will be delivered live by RSU bridges if an Internet connection will be available, with one additional in-vehicle camera stream. In case no stable connection will be available, pre-recorded data, highlighting different critical situations in which visualized V2X data supports the driver, will be shown.

The prototype hardware for the in-car *CODAR Viewer* is depicted in Fig. 1 (b). Fig. 2 (a) shows the general system architecture. A Linux PC with GPS receiver, CAN and OBD interface presents information on either a Google or Yahoo map to the driver via a local web server. The map data is



(a) Current Setup using IEEE 802.11a on 5.7 GHz (b) General Setup using IEEE 802.11p on 5.9 GHz

Figure 2. The current V2X system (left) setup consists of a Linux-based PC with GPS, CAN and OBD interfaces and a GUI on a touch screen monitor. 802.11a WLAN simulates 802.11p networking hardware on a similar frequency until the final communication hardware is available. The right figure shows the envisioned system setup that e.g. also comprises off-line maps.

acquired by an additional mobile broadband connection. The information is processed by the algorithm toolbox component and presented to the driver on an additional screen in the car. The physical MAC layer used in European V2X communication, IEEE 802.11p, is currently "simulated" by an IEEE 802.11a Atheros WLAN network card using a similar frequency as with the final system. The card supports ad-hoc networking with other 802.11a systems. The physical system currently used uses one car on-board unit and one road-side unit. Other vehicles are simulated and integrated in the visualization.

5. Future Work and Outlook

The CODAR Viewer for the driver will runs integrated on an in-vehicle HMI, like a fixed navigation unit with touch screen display. The *CODAR Viewer* will, in future, allow both online and offline maps, removing the necessity for an additional broadband connection. Localized maps and map updates will use the V2X communication link via IEEE 802.11p to a RSU or by map-sharing amongst vehicles. The general system overview of the next iteration using a specialized V2X on-board unit is depicted in Fig. 2 (b).

User studies on the HMI are envisioned for mid of 2008. The 802.11p-based infrastructure is currently installed on our test site.

References

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