Denne artikel er publiceret i det elektroniske tidsskrift
Artikler fra Trafikdage på Aalborg Universitet
(Proceedings from the Annual Transport Conference
at Aalborg University)
ISSN 1603-9696
www.trafikdage.dk/artikelarkiv

Implementation of CVIS ITS Application in a Driving Simulator Environment

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Abstract

In order to test an IVIS (In-Vehicle Information System) in a simulated environment a concept for using CVIS (Cooperative Vehicle-Infrastructure System) based application in a driving simulator is proposed. The system provides the application, an incident warning application, with position data for the simulated vehicle and data regarding the road network. For the test described here, an existing demonstrator application for a real vehicle was modified to accommodate the needs of the simulator. The core functionality for the application remained the same as for the real life system, while components providing positioning and incident data were changed. This paper describes the technical implementation of the system and outlines some of the experience gained from the test. It also gives a presentation of the importance of testing cooperative systems in a simulated environment.

Introduction

The goal of this paper is to provide a conceptual and technical description of a cooperative system implemented in the driving simulator at SINTEF, as well as describe one of the applications that have been used and tested in the simulator. Finally the paper will describe some of the future plans for the systems and some of the possibilities an installation like this gives.

Cooperative systems may give a large variety of benefits ranging from better traffic efficiency and improving traffic safety to better information services and environmental benefits [3]. Implementation of such system on a large scale are important for stakeholders like road operators, but providing knowledge about their effects on drivers on both a small and large scale can be difficult. This paper describes the technical properties of a system able to address some of the challenges in evaluating cooperative systems. To create the traffic safety systems of the future, giving the vehicle access to real time data like data from road side sensors, other vehicles, and even weather forecast, makes it possible to develop new and innovative solutions that can cope with both current and future traffic safety and efficiency challenges. This paper mainly focuses on one category of applications, In-Vehicle Information System (IVIS).

The design of IVIS applications must be innovative and easy to use and must not in any way represent a disturbance to the driver. Key factors to achieve this are access to high quality real-time data and an easy-to-use and intuitive user interface. To be successful, it is crucial that the IVIS applications are tested with respect to the above mentioned design goals. Such tests can be difficult and even dangerous to perform in real traffic.

For many IVIS and ADAS systems the use of experimental studies are needed since observational studies are impossible to perform because the products are not mass produced or common in vehicles [1]. A possible solution is to do a behavioural study of the IVIS applications in a realistic but controllable and safe environment, like a driving simulator. In a driving simulator the test subject can drive in a close to real world traffic environment, which includes both realistic roads and other traffic. The challenge is how to integrate an IVIS system into a simulated environment, and still be able to maintain its functionality.

To be able to do this, it is important to understand how the IVIS system is built and to map out the different interfaces between important modules within the system, and with the outside world. If possible, it is best to let the different modules communicate with the real world system, so if the system needs for instance real-time data about weather condition, it may retrieve the data directly from the weather forecast service provider. This kind of data can however be quite dynamic by nature, making it difficult or even impossible to do comparative studies using them. It is therefore important to remember that the study is about the design of the IVIS system, not necessarily the data. In a scientific behavioural experiment it is usually desirable to keep for instance the weather conditions the same for all test subjects, while testing different versions of the IVIS user interface.

In cooperation between the projects Wise Car (Research Council of Norway), ITS Test Beds (EU project) and GOFER (Research Council of Norway) SINTEF together with other partners developed two demonstrator IVIS applications for use in real vehicle. The projects wanted to utilize CVIS (Cooperative Vehicle-Infrastructure System) technology developed in the EU project with the same name, and had an interest in testing real applications on the CVIS equipped test arena Test Site Norway, located in Trondheim. CVIS is a quite generic system with utilize open standards like OSGi and the Java programming language.

The two demonstrator applications where ISA (Intelligent Speed Adaptation), which informs the driver about the current speed limit and gives a warning if the driver is exceeding the speed limit, and Incident and Hazard Warning, that informs the driver about potential dangers in the road system, like wild life on the road and accidents. For the installation described here only the Incident Warning Application was used. In the real-life version of these applications the data source was a service called TRIP (Transport Related Information Platform) developed in the project WiseCar. TRIP integrates data from several different sources, both public and private, and makes them available on one common standardized interface. In the simulator all data where faked to give the desired test conditions.

The ITS Test Beds project aimed to define a common test infrastructure for sharing results from ITS test sites across Europe. This involved building a prototype service for sharing test data. As a consequence of this the TASC (Test Aggregation Service Center) was developed. The service allows different test sites to send test data through a SOAP interface, and retrieve and reuse these data later. It also allows for sharing of data in near-real time, a feature that was tested in this project using the Incident Hazard Warning in the driving simulator and sharing data in real time with DLR's cooperative software CODAR (Cooperative Object Detection and Ranging).

Implementation of the test application

All installation and tests where done in the SINTEF driving simulator in Trondheim. The simulator is a fully immersive environment with two available configurations, one complete Renault Megane Scenic car and a Renault Magnum truck cabin. Three large backlit screens, each covering a sector of 60 degrees gives a 180 degrees front view, shown in Figure 1. In addition the simulator has a back visual system consisting of two projection systems displayed on a white wall behind the vehicles. Scenario building and monitoring tools are based on the Oktal SCANeR simulation engine, which is designed with scientific experiments in mind.

Figure 1 The driving simulator

The test system is based on the CVIS reference platform, described later, and consists of a touch display mounted inside the driver cabin which is connected to the CVIS host computer. In order to get the system working the host computer needs to be connected to two separate networks, one common internet connection from where the IVIS application can receive map updates or other data if needed, and a dedicated UDP network which provides GPS data and the custom made road traffic messages. The schematic layout of the system is shown in Figure 2.

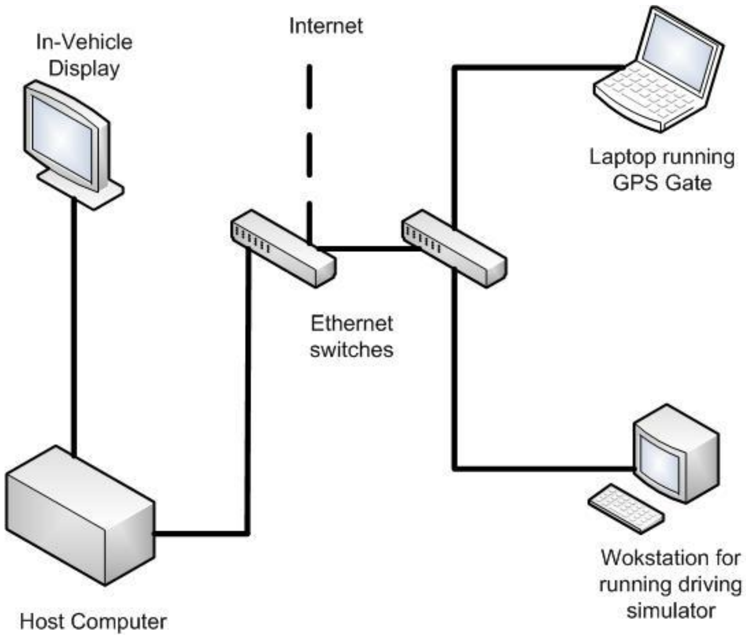

Figure 2 System setup

The integration platform for the system was based on the CVIS (Cooperative Vehicle-Infrastructure System) reference platform, developed by Q-Free. A complete installation for a regular vehicle consist of two computers, one application host, running user applications and one router, handling the network traffic and doing all positioning calculations, shown in Figure 3.

The installation used in the simulator however, will not be doing any positioning calculations and the network routing duties are small compared to that in a real world scenario, so in the test setup only the host computer and the display were used. This simplified the setup and removed the need for any proprietary hardware and enables the system to be used on any runtime environment, not necessarily OSGi. OSGi is part of the CVIS reference platform, and therefore used for these tests.

Figure 3 CVIS reference platform components

OSGi is a service platform for the Java programming language that implements a complete and dynamic component model enabling components and applications (called bundles in the OSGi terminology) to be remotely installed, started, stopped and uninstalled without requiring the system to reboot. All OSGi applications are programmed in Java.

Getting position data to the application was one of the main challenges in the implementation, since devices used for IVIS application use GPS and other sensors like odometers and accelerometers to estimate current position, which also holds true for the CVIS system. There were several ways that these sensors could be simulated in a driving simulator environment. One possible solution was using radios simulating GPS, but these devices are expensive and not really viable in this case. Using a regular computer network to transmit the position data, is relatively cheap to implement, but isn't supported by a lot of devices that use internal GPS, but it however possible to do on the CVIS system. The latter method was chosen to demonstrate the feasibility of the scheme and build this test installation.

In the driving simulator, GPS messages and road messages are generated using SINTEF developed software. This software enables the simulator to send position messages to the vehicle every second. Road messages are sent at predefined positions along the simulated driving route. Both GPS messages and road messages are relayed to the CVIS equipment using a laptop running Franson GPS Gate, which pass data on a dedicated UDP channel, shown in Figure 2.

All data exchange between the simulator and the IVIS application was done using the NMEA0183 protocol. This protocol was chosen since it enabled the necessary data to be transmitted via the GPS Gate software which had been used in previous projects, and therefore already installed and working in the simulator. By using this protocol and defining additional proprietary messages it was possible to send position data and build traffic messages similar to that from TRIP in the real vehicle. A new module for handling the new format of the messages was developed and installed in the CVIS environment. The GUI (Graphical User Interface) modules and modules for interpreting the message content and reacting to it were left unchanged.

To get usable position data from the simulator, the environment data base was set up so that the coordinate system in the simulator matched with that of the real world. Position data (latitude, longitude, heading and speed) where transmitted every second on the simulator network. During the tests a simulator scenario based on the road network in and around Trondheim was used.

To integrate the simulator with TASC, the test site integration tool from the ITS Test Beds project, some additional software modules for collecting and transmitting the necessary data were developed. These data could be read by CODAR Viewer in near real time. CODAR Viewer is a simulation and visualization toolbox for vehicle to vehicle communication. It visualizes communication, creates awareness and provides situation information. Visualized vehicle-to-x (V2X) 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 and the driver's free mental capacities [4].Figure 4 shows the CODAR Viewer user interface.

TASC is a SOAP based portal which allows applications to forward test data in a specific format and stores these data in an organized fashion into the a data base. All data are organized in test runs, which are well defined sequences of test messages. By having all these data available in one portal, sequences from one or several different test runs can be analysed later. TASC also has a message queue enabling messages to be read in near-real time, a feature that the test application used.

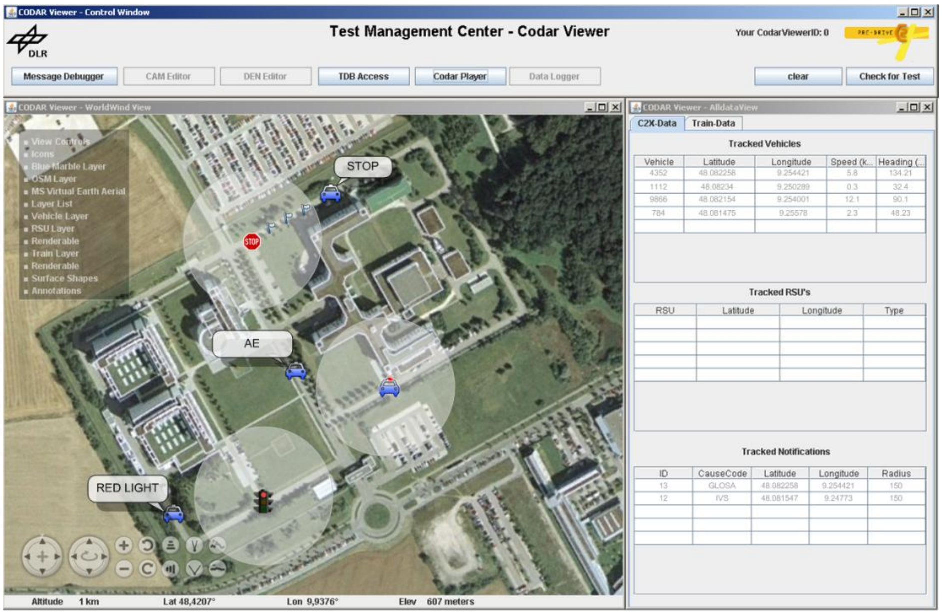

Figure 4 The CODAR Viewer visual interface (DLR)

Experience and discussion

This development and test have shown that testing cooperative ITS systems on a generic platform, like CVIS, in a simulated environment is feasible and can be done in a simple and cost effective way. For this test actual CVIS equipment was used since it was available, but the integration could have been done using off the shelf components like regular PCs. The OSGi environment will run in both a Window and Linux based environment.

In order to obtain usable data from the simulator it is important that the cooperative system under test has precise and repeatable behaviour. This means that incidents and events are triggered at the same location every time. The system was used as case for behavioural studies on the above mentioned Incident Warning System. Focus for this test was moose and congestion warning. Half of the test subjects drove with the IVIS system and the other half only had regular warning systems like signs available. In order to get an estimate on how the subject reacted to the IVIS system, the warning had to be given at the exact same distance from the incident for all test subject, otherwise it would be hard to compare the results from each test. The system described here was able to provide the desired precision and gave good results for the behavioural study.

Figure 5 Picture from incident warning tests

Analysis of the generated data has shown that the relatively simple Incident and Hazard Warning application described here had a promising effect on driver behaviour, with regards to the chosen speed and the alertness to incidents [8]. Figure 5 shows the system in use in the driving simulator during the study.

Integration with other test systems, both TASC and CODAR, was successful and demonstrated that the simulator can appear as a real-life system in its current configuration. This means that tests that are done in the simulator can be logged in TASC and comparative studies with simulated and live data can be done for example to validate the simulator for certain kind of test. The data does not even have to be from the same organisation.

Further work

During the implementation of the system described in this paper it became apparent that the system as it is today can fuse data from both the real world and the simulator. The system can read real data direct from TRIP, giving the simulated vehicle access to real data about the road network, like for instance:

- Logical road network
- Road attributes
    - Speed limits
    - Road user class
    - Road lane width
    - Height restrictions
    - Turn restrictions
    - One-way roads
- Road incidents
- Weather data

This enabled the system to use real life data in a simulated environment which can be interesting for testing different kinds of systems like for example intelligent speed adaptation, eco-driving assistants and dynamic routing, giving a lot of flexibility in the future.

Since the coordinate system used in the simulator scenario data base is identical to the real life coordinate system, the driver in the simulator can see his or her car drawn on a actual electronic map provided by for example Google or Open Street Map, with data from the simulator like for example other vehicles drawn on top of it.

And this is where some of the interesting research lay. By providing the IVIS system with data from other simulated vehicles, more advanced cooperative applications like collision warning, sharing of real-time data like the ESP experiencing slippery road conditions can be tested. SINTEF also has a truck simulator where similar applications for professional drivers can be tested.

During the later half of 2011 SINTEF plans to integrate the same type of cooperative system in the truck simulator and test applications that will be used in real vehicles later as part of a demonstrator in the National Project GOFER (Goods Transport on Suitable Routs, Norwegian acronym). In addition a similar system for Android based units is also being planned.

Conclusion

This paper has given a brief overview of the main principles and the architecture concerning a cooperative test system for the SINTEF driving simulator. The system can be built using off the shelf components and most common operating systems. Results from the testing the system was so promising that the system described here was used for a behavioural study on an Incident and Hazard Warning application.

Cooperative systems are currently difficult to test under real life conditions, both because they address situations that has the potential to harmful to the driver, but most importantly the systems themselves aren't available on a scale large enough to produce usable results. Getting data on how these systems influence driving is still important in order to promote their use. This system provides a platform to address some of the questions regarding the effects of cooperative systems.

The system as it is today is quite flexible and can be expanded to fuse data from both simulated and real sources, enabling research on more advanced cooperative concepts like collision warning in the safe environment of a lab. This was demonstrated by sending data from the simulator to TASC and CODAR viewer as part of the ITS Test Beds project. A similar system is being planned for the truck simulator at SINTEF.

The system is mainly based on off the shelf software and hardware in addition to some SINTEF developed software. Currently the installation is based on the CVIS project but plans for expanding the system to also run Android units is being planned. The system has already been used for scientific testing on behavioural studies.

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