A Map Based Driver Warning System

Karsten Heinig
Institute of Transport, Road Engineering and Planning
University of Hannover
Appelstraße 9A, D-30167 Hannover
heinig@ivh.uni-hannover.de
Phone: +49 511 762 23 84
Fax: +49 511 762 25 20

Wilhelm Vogt
Business Unit Driver Information Systems, Blaupunkt GmbH
P. O. Box 77 77 77, D-31132 Hildesheim
wilhelm.vogt@de.bosch.com
Phone: +49 51 21 49 49 90
Fax: +49 51 21 49 17 49 90

Dr. Christoph Hecht
TRANSVER GmbH
Maximilianstraße 45, D-80689 München
hecht@transver.de
Phone +49 89 211 87 80
Fax +49 89 21 18 78 22

Dr. Michel Mittaz
Institut de Recherches Robert Bosch S.A., CR/ARS
Route de D Menges 2, Case postales 12, 1027 Lonay, Switzerland
michel.mittaz@ch.bosch.com
Phone: +41 21 804 72 44
Fax: +41 21 804 72 05

Abstract

The horizontal PReVENT subproject MAPS&ADAS develops a map based Driver Warning System, consisting of an ADAS map, the Speed Limit Warning and the Hot Spot Warning Application. This application warns the driver in case he is approaching a certain location in the street network in a manner which has a potentially high risk of an accident in the next seconds. The hot spots are generated offline beforehand using police reports of accident and put into the ADAS map. During the drive the data is communicated from the ADAS map to the Warning Application via the ADAS-Interface. The Hot Spot Warning application compares the attributes of the hot spots with the variables of the current ride, like location, speed, time of day, weather, moisture and lighting conditions and calculates in a 1 Hz frequency the risk. If certain values are reached, a warning to the driver is issued. This application will be technically validated and the safety effects will be assessed, using the recently developed and validated power model to estimate the increasing traffic safety. The tests will be carried out in the next months and the results will be presented.

Motivation

Still every year about 40,000 people die on European roads in road accidents. To reduce the related high costs of transport, the European Commission has stated in its white paper different measures to improve traffic and road safety [1]. One of these measures is to improve road safety by using intelligent vehicle safety systems. PReVENT [2] as an Integrated Project of the 6th European Framework Programme contributes to these goals.

Concept

MAPS&ADAS as a horizontal subproject of PReVENT develops amongst other things a map based Driver Warning System, consisting of an ADAS map and the two applications “Speed Limit Warning” and “Hot Spot Warning”.

The ADAS map is a commercial map enriched with safety relevant attributes, which will be used by the two warning applications and represents the data base for both driver warning applications. It includes the specified hot spots, as well as the speed limit data specified according to the SpeedAlert project [3]. It will be assessed using the Driver Warning System as a means to show the safety effects of a Safety map respectively ADAS map. The mentioned Hot Spots for the MAPS&ADAS Hot Spot Warning application are defined as road segments or a specific place on the road that represent an increased risk of accident to a driver. This may, but does not need to, correspond with an extraordinary number of accidents in the past. Hot spots are often generated by accident data collected by police and stored in databases at statistical state offices.

In general a hot spot is characterised by a surprising change in the road characteristic that a driver may not realise in due time when driving at an excessive speed or lacking concentration. A hot spot may be limited to specific environmental conditions (e. g. freezing temperature, darkness).

The Speed Limit Warning application aims to prevent drivers from speeding by using the ADAS map with additional ADAS attributes, which is in this case the information about legal speed limits. It will warn drivers in case they are exceeding the speed limit stored in the ADAS map. It has been shown that in car devices like active accelerator pedals or speed information displays lead to a reduction in driving speed (e. g. [4-6]).

It is obvious and has also been shown in many researches that a decreasing of speed will improve traffic safety [7, 8].

Elvik et al. [9] present an evaluation of the power model
describing the relationship between speed and accident results, which shows that a strong relationship between the reduction of speed and the reduction of numbers and mitigation of consequences of accidents exists.

The Hot Spot Warning Application seeks to increase traffic safety by warning drivers in case that they are approaching a location in the street network in a manner, which has a potentially high risk of an accident. To identify such a high risk, a hot spot is identified and put into the ADAS map by the map supplier. So far, only one similar approach is known and the published results deal with feasibility assessment of the approach [10].

Both applications of the Driver Warning System are designed in a similar way. They both use a GPS positioning system, a digital map which stores the relevant safety or ADAS attributes like speed limits and hot spots and they both evaluate the actual driving situation and compare it to values stored in the ADAS map to decide whether a warning should be issued to the driver. The data is transmitted to the application via the ADAS-Interface (cp. Figure 1). The details of the specification, development, testing and validation of the ADAS-Interface can be found in the respective documents [11-16]. This paper discusses the aspects of the Hot Spot Warning Application.

Data Sourcing and Availability

The Hot Spot Warning Application concept provides an anticipatory warning of (potentially) dangerous sites in the road network depending on environmental influences and current driving dynamics. Therefore different data of the actual ride have to be assessed continuously:

- current location, heading, speed of the vehicle,
- details on the circumstances of the actual ride (vehicle data),
- environmental conditions (lighting, temperature, rain/moisture)
- ADAS map: coded dangerous places (hot spots) and details on the nature of the danger

The circumstances of the relevant accidents that happened in the past are available via the accident reports collected by police. For this research the data of the Statistical State Office Lower Saxony was analysed. The results are used to define and code hot spots in a specific format and store them in the ADAS map, in order to be exploited by the Hot Spot Warning Application.

Map or navigation related data like position, route, etc. will be made available via the ADAS-Interface. Other sensors' data, e.g. from the wipers, rain sensor or headlight will be provided through the vehicle data bus.

Hot spot warning as it will be implemented within the MAPS&ADAS project will not address the generation of warnings according to dangers that cannot be derived from accident data without any comprehensible relation to the road network (e.g. inattention of the driver or alcohol related accidents, etc.). The hot spot warning considers different types of dangers, which can be identified by a local accident-based hot spot (due to accident clusters) and such which can be transformed to general attribute-based hot spots (due to specific road attributes and the geometry of the digital map).

Hot spots are composite attributes attached to a road element in the digital map. A hot spot consists of:

- an unique ID to identify it,
- a time validity period to specify hot spots which are only valid during certain times of day, week or year
- a warning category to specify the nature of the potential danger to the road user (like dangerous curve, slope or game animals during spring and autumn). The kind of warning display to the driver depends on this value, amongst other things.
- a validity direction and
- several profile spots, since a hot spot is modelled as a rectangular discrete profile along the road element. Each of the profile spots has an offset, calculated from the beginning of the road element and a Warning Level Matrix. This matrix specifies a level of danger for every combination of environmental data of temperature, moisture and lighting conditions.

The Hot Spot Warning Application

The Hot Spot Warning Application calculates a so called preview distance depending on the actual driving speed and the user and system settings. These setting are for example the driving style (e.g. sportive, cautious) or a
general modification of the warning threshold for testing purposes. A warning is generated if a hot spot is detected within this preview distance.

If a hot spot exists, the hot spot category will be read and the environmental conditions are calculated from the vehicles sensor data, like temperature, moisture and lighting conditions. These variables are then used to get the warning level from the warning level matrix; the warning level is then used to calculate a warning speed. If the actual driving speed is higher than this warning speed, a warning will be generated according to the hot spot category and displayed to the driver.

The described mechanism is repeated with a frequency of 1 Hz.

Assessment of Safety Effects

The safety effects of the Driver Warning System and especially of the Hot Spot Warning Application will be assessed analysing of the following impacts:

- reduction of speed when approaching a hot spot,
- decreasing number of accidents and
- reduction of dangerous driving situations.

Since only speed can be measured directly, indicators have been defined to reflect these assessment objectives. Especially a decreasing number of accidents cannot be analysed during the tests, so indicators must be found which can reflect the impacts.

The chosen indicators are

- speed near a hot spot and
- conflicts.

The change of speed will give an indication of the change of traffic safety using the power model proposed by Nilsson [18] and recently validated by Elvik [9]. The model is:

\[
\text{accident rate}_{\text{after}} = \text{accident rate}_{\text{before}} \cdot \left( \frac{V_{\text{after}}}{V_{\text{before}}} \right)^x
\]

The exponents in Table 1 summarise the effects of changes in speed.

<table>
<thead>
<tr>
<th>type of accident results</th>
<th>exponent</th>
</tr>
</thead>
<tbody>
<tr>
<td>fatalities</td>
<td>4,5</td>
</tr>
<tr>
<td>fatal accidents</td>
<td>3,6</td>
</tr>
<tr>
<td>Seriously injured road users</td>
<td>3,0</td>
</tr>
<tr>
<td>Serious injury accidents</td>
<td>1,4</td>
</tr>
<tr>
<td>Slightly injured road users</td>
<td>1,5</td>
</tr>
<tr>
<td>Slight injury accidents</td>
<td>1,2</td>
</tr>
</tbody>
</table>

The term conflicts refers to the Swedish Traffic Conflict Technique [19] and an in-car observation method, first developed by Risser [20], used in many studies to analyse driver behaviour (e.g. [21]). A conflict is defined as a near-miss accident. Serious conflicts are, like traffic accidents, a result of a breakdown in the interaction of the road user, the environment and the vehicle. A serious conflict has the same development of events as an accident, with the exception that collisions rarely happen in conflicts and few if any are injured. Hydén states the number of conflicts for each police-reported injury accidents between 3,000 and 40,000, depending on the severity and type of conflict [22]. The conflict technique was taken further by Svensson [23] who validated the relationship between traffic events according to a severity hierarchy.

The assessment will be carried out by test drivers and their change of behaviour when driving with an activated Driver Warning System will be analysed. A drive without the activated system will serve as reference case, which will be the base to assess the impact of the Driver Warning System to the driver.

The assessment will be done using an instrumented car, equipped with the Driver Warning System and sensors and cameras to record driver behaviour (2D accelerometers, video cameras) to enable an adequate assessment of the driving behaviour and the safety effects, additional information will be logged during the test rides.

Outlook and Conclusion

The application will be implemented within the next months and put into extensive functionality tests. After the successful finish of these tests, the safety effects will be assessed. It can be expected that the traffic safety will increase significantly, shown by the reduction of indicator “speed” during the tests and the reduction of conflicts during the test rides.
References


2. PReVENT-Consortium, PReVENT - Objectives. 2005, ERTICO.


19. The Swedish Traffic Conflict Technique, Department of Technology and Society at Lund University: Lund.


