SESSION 3:
VULNERABLE ROAD USER: OTHERS
Personalised hazard warning system for safety improvements of vulnerable road users

Olaf Czogalla & Andreas Herrmann
Institut f. Automation u. Kommunikation ifak
Steinfeldstraße 3
39179 Barleben, Germany
Phone: + 49 (39203) 81049
Fax: + 49 (39203) 81100
E-mail: Olaf.Czogalla@ifak.eu

1 Introduction

The combination of selected Intelligent Transport Systems (ITS) technologies allows for individualisation of traffic information to improve traffic safety of vulnerable road users. This paper presents a short outline of recent international research results in this area, [1] [2]. The proposed method and prototypic technical solution described in the paper is based on the concept to keep the motorised traffic up-to-date with location based and individual information about accident risk spots and hazards in an urban or inter-urban street network.

For traffic participants who are not familiar with a local urban traffic system it is more difficult to concentrate on additional warning signs. In particular if traffic signs are overlooked or accident hazard spots are not recognised by the driver, additional advice could be helpful. Examples of such dangerous spots are junctions with rail track crossings where trams have the right of way or pedestrian crossings where turns for cars are allowed on red as well as bicycle lanes at poorly visible road curvatures.

The personalised risk warning system was implemented using the following components. Information regarding hazards and accident risk spots was provided from different sources such as collections of car accident report data involving injuries of pedestrians and cyclists. The acquired data collection was localised with geographical co-ordinates using suitable methods of either address based geo-coding or location based geo-referencing. A classification of hazard types is needed with respect to involvement of pedestrians, severity, frequency of occurrence as well as other categories in order to assign appropriate warning messages for hazard classes identified.

For a delimited region like a city, relevant hazard warning messages are stored in a geo-referenced database from which regularly updated messages can be broadcasted by Digital Audio Broadcasting (DAB) to be received by digital car radios. For the display and announcement of hazard warning messages, a standard PDA with positioning capability and wireless connection to the digital radio was used.

The current vehicle position during driving is continuously compared to hazard message coordinates of the geo-referenced message table. For any matched locations of hazard spots, the according messages will be announced by speech and displayed to the driver. The technical solution described can also be adapted for usage in connection with commercial mobile navigation systems.
2 Analysis of accident risk spots

Annual traffic safety reports compiled and published by police departments for their districts contain highly qualified information on location and causes of traffic accidents as well as the involvement of pedestrians or cyclists. Whereas the traditional paper maps with coloured pin markings are still in use, digital maps in combination with recorded GPS coordinates for accident locations are becoming increasingly standard for accident reporting.

The availability of digitally localised accident data enriched by attributed information facilitates cluster analysis by means of Geographic Information Systems (GIS) to identify accident risk spots depending on selected criteria such as the involvement of vulnerable road users.

The geographic location can be recorded during acquisition of accident data using a GPS receiver that is usually integrated in specialised handheld devices or on-board navigation systems. Alternatively, the location can be referenced by city street addresses through subsequent post-processing in a GIS like ArcView with extended network analysis functionality. The address-based localisation function allows the process of tabular address data to obtain geographic coordinates based on interpolation of a given numbering scheme for street segments.
The accident report form contains fields for addresses including numbers to pinpoint accident locations in built-up areas as precise as possible. Outside developed areas, distances to next intersections or roadside mileposts are used to identify the incident spot. All accident reports of a police district are usually stored over a period of one year in a database in the form of tabular data that can be directly connected for access through the GIS or exported for further conversion into GIS shape files, as shown in Figure 2.

### 3 Generation of a georeferenced traffic safety map

Once the geo-referenced database of accidents containing classified information on causes and involvements of road users is available, an attributed cluster analysis is carried out that enables the generation of a map overlay with standardised warning messages. For the cluster analysis attributes such as kind of injured persons or accident causes are combined in a query over the accident database. The result of a query combines a unique set of accident classes for which certain warning messages can be assigned. The more special a query is formulated, the more geographical interrelations can be recognised. Geographically interrelated accidents form a cluster of multi-points that can be combined into one accident hazard spot within the traffic network.

All identified hazard spots with their corresponding warning messages form the geo-referenced traffic safety overlay table that can be mapped onto the street layer. Examples of warning messages are given in Table 1. Tram stops were also added to the message table because of the high imminent accident risk at tram stops with insecure passenger crossings.

<table>
<thead>
<tr>
<th>ID</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Direction</th>
<th>Warning message</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52.5533</td>
<td>11.3245</td>
<td>123</td>
<td>Attention – Accident risk spot – Mind crossing cyclists</td>
</tr>
<tr>
<td>2</td>
<td>52.5731</td>
<td>11.3195</td>
<td>089</td>
<td>Attention – Accident risk spot – Mind tram priority</td>
</tr>
<tr>
<td>3</td>
<td>52.5123</td>
<td>11.3789</td>
<td>302</td>
<td>Attention – Accident risk spot – Merging lanes ahead</td>
</tr>
<tr>
<td>4</td>
<td>52.5786</td>
<td>11.3235</td>
<td>005</td>
<td>Attention – Accident risk spot – Mind crossing pedestrians</td>
</tr>
<tr>
<td>5</td>
<td>52.5256</td>
<td>11.3295</td>
<td>145</td>
<td>Attention – Tram stop – Passengers crossing street</td>
</tr>
<tr>
<td>6</td>
<td>52.5456</td>
<td>11.3285</td>
<td>180</td>
<td>Attention – Right of way changed</td>
</tr>
<tr>
<td>7</td>
<td>52.5365</td>
<td>11.3213</td>
<td>010</td>
<td>Attention – Traffic lights out of order</td>
</tr>
<tr>
<td>8</td>
<td>52.5289</td>
<td>11.3789</td>
<td>146</td>
<td>Attention – Crossing bicycle lane ahead</td>
</tr>
<tr>
<td>9</td>
<td>52.5735</td>
<td>11.3456</td>
<td>052</td>
<td>Attention – Park and Ride facility ahead</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

The warning messages are also defined by the direction of their validity that is equal to the direction of travel or heading of the vehicle. The direction of validity is given in azimuth degrees defined as 0 degrees for north, 90 degrees for east, 180 degrees for south etc. Each message direction can exactly be determined using a layer of line objects from a digital street map. For this purpose, the message coordinates are aligned to the corresponding street segment to determine its referenced direction or opposite direction respectively, depending on the intended direction of action.

For each unique message a short voice file in MP3 format is recorded for its vocal announcement. The audible announcement of warning messages is essentially required to support the message display and to minimise the distraction of the driver. The warning message table and voice files are regularly updated and transmitted to the DAB network operator for broadcasting.
4 Regional data transmission using Digital Audio Broadcast

Various studies carried out in connection with the European project PRETIO [1] have revealed the high potential of digital car radio as a preferred source of on-trip traffic information. The available bandwidth of digital audio broadcast transmission allows one to deliver multimedia data at high update rates. Modern commercial handheld devices equipped with excellent display capabilities in combination with digital radio allow the creation of applications that exceed the capabilities of currently used FM based traffic message channels.

The services successfully validated for their marketability in three European countries were such as traffic condition maps, roadwork sites and lane closures, free parking places in cities, traffic camera imaging and travel times.

For the reception and display of services in the car environment, only available and introduced products were combined using the wireless connection standard Bluetooth. The central element is the digital car radio which receives and decodes the data services. A Personal Digital Assistant (PDA) is connected to the digital car radio over Bluetooth as well as to a GSM handset to provide a backchannel and a wireless GPS mouse for the purpose of positioning.

The DAB standard defines the transmission of digital data having bandwidths of up to 64 kBit per second in contrast to 2kBit per second for RDS-TMC (Radio Data System-Traffic Message Channel) data transmission used for conventional traffic messages over FM radio. Thus, the update cycle for a fixed amount of data is considerably reduced. In addition, new standards for transmission of traffic information like TPEG (Transport Protocol Experts Group) [3] that use digital media such as Internet, Digital Audio Broadcasting or Digital Video Broadcasting (DVB) have been developed and applied in numerous cases.

The TPEG standard was developed by the European Broadcasting Union (EBU) in cooperation with the European Union for transmission of digital traffic and transport information. The Transport Protocol Experts Group is a group of experts led by the EBU coming from all areas of the Traffic and Travel Information businesses, as well as broadcasting. The group developed the TPEG specifications for transmission of language independent multi-modal Traffic and Travel Information.

The main advantage of TPEG compared to TMC is the independence from a predefined location code list and the possibility to transmit any content in a message container because
it is not bound to a fixed set of message texts. Messages can relate to any location because the reference is based on WGS 84 coordinates that are used by GPS.

Examples of typical TPEG applications are:
- RTM - Road Traffic Message
- PTI - Public Transport Information
- LOC - Location referencing, used in conjunction with applications
- PKI - Parking Information
- CTT - Congestion and Travel-Time
- TEC - Traffic Event Compact
- WEA - Weather information for travellers

Developments for delivering Parking Information and Congestion and Travel-Time information are underway. The European Union has also funded work in the project Global System for Telematics (GST-IP) for Safety Channel message delivery which is based on TPEG technology will be tested at a number of test sites during 2006/2007. Safety Channel will establish an agreement on a set of protocols and interfaces which fulfil the requirements of a bearer independent, real time, high priority message channel, see Figure 4 [4].

Figure 4 Safety Channel Communication Chain (Source: GST)

Safety related contents from content providers such as automobile clubs, police, federal and local authorities or even Floating Car Data (FCD) are transmitted and processed in Safety Channel Service Centers and broadcasted over playout centers of radio network operators. The DAB based service is received by the client system usually via a DAB receiver and a so called "nomadic" PDA.

Under these technical preconditions the broadcast of geo-referenced warning messages is particularly feasible using the TPEG standard, whereas also a file based transfer using the Multimedia Object Transfer Protocol (MOT) is practicable.

A client application at the PDA processes continuous coordinates and directional heading being sent over the wireless connection from the GPS receiver and compares the position with locations, distances and directions of the warning message table. If the position of the
vehicle is in the predefined range and the directional heading including a tolerance equals
the stored direction, the warning message is announced and displayed. Message tables are
constantly updated without any user action necessary. The broadcast range and required
data volume can be restricted to an urban area by using only the local DAB bands for
transmission instead of state wide DAB bands covering large parts of countries or complete
provinces.

5 Design principle of service and nomadic device

The use of "Nomadic Devices" or portable devices within the vehicle by a driver aimed for
support, assistance, communication or entertainment, is increasingly common. As in-car use
of Bluetooth mobile phones, handheld computers, portable navigators and personal music
players grows rapidly, there are concerns that this could lead to driver distraction and
increased safety risk. There is also a lack of standards for device "docking" in the vehicle,
and for safe installation and use.

Increasingly, all of these types of devices are being offered as original equipment or
aftermarket options by car manufacturers. This growth is in response to customer demand,
but it does create important issues for driver safety, for the human-machine interface (HMI)
and for the integration of the devices into the vehicle.

The European Commission has issued recommendations on safe and efficient in-vehicle
information and communication systems to assure their safe use based on results of the joint
industry-public sector e-Safety Forum that established a working Group on human machine
interface, which produced its final report in February 2005. The principal design goals
adopted are described as follows.

1. The system supports the driver and does not give rise to potentially hazardous behaviour
   by the driver or other road users.

   An important overall requirement can be simply stated as ‘Do no harm’. This means that the
   system should enhance or at least not reduce road safety. The approach taken by this
document is to systematically guide a system's designer by principles addressing design
relevant aspects like installation, information presentation or interface. This is because the
overall effects may not be entirely predictable or measurable since they depend not only on
the system design but also on the individual driver and the driving task/traffic situation.

2. The allocation of driver attention while interacting with system displays and controls
   remains compatible with the attentional demand of the driving situation.

   The driver has a limited but variable attentional resource and physical capacity which can be
distributed dynamically by the driver between tasks. The resources activated by the driver
depend not only on personal factors but may also vary according to his motivation and state.
Interfaces (including visual, tactile and auditory) can induce both physical and cognitive
workload.

3. The system does not distract or visually entertain the driver.

   The aim of this principle is to ensure that the driver is distracted as little as possible by the
use of a driver information or communication system while driving such that his/her ability to
be in full control of the vehicle is not compromised. This design goal is also formulated to
highlight the special importance of avoiding distraction caused by visual entertainment.

4. The system does not present information to the driver which results in potentially
   hazardous behaviour by the driver or other road users.

   The content of the information should not encourage the driver to engage in behaviour
which may increase the risk of an accident while driving. A hazardous behaviour may
influence other road user behaviour. An example could be the display of a race-driving-
strategy in order to achieve a maximum speed while cornering. Other road users may be concerned if the hazardous behaviour of the driver occurs when he/she is interacting with them, as well as if the system generates signals perceptible from the exterior which may induce erroneous interpretation by other road users, and possibly dangerous manoeuvres.

5. Interfaces and interface with systems intended to be used in combination by the driver while the vehicle is in motion are consistent and compatible.

All HMI components of individual systems should be designed according to principles for single systems and this will give a minimum level of consistency. However, consistency can still be an issue between individual well designed products.

6 Prototypic solution

The prototype system was developed to process warning messages in the German city of Magdeburg. The majority of warning messages was generated using geo-referenced accident reports of the Magdeburg Police Department. Additional messages were created by information about hazardous spots in the street network from the municipal planning authorities. Information on road works and closed lanes were provided from road traffic authorities of the city and the state. Furthermore, all tram stops were included as warning message locations.

The system was developed to also display additional traffic information such as traffic camera images from over 40 traffic cameras that were developed, built and maintained by the authors Institut f. Automation u. Kommunikation (ifak) in Magdeburg. These services were created and successfully validated with the support of the European project PRETIO, for in-depth information about the project and DAB based traffic and transport services refer to [1]. Based on the design principals described in chapter 5, the information presentation principals for a prototypic solution using the introduced terminal components were derived. Their impact on the driving task is discussed in the following.

Figure 5 Wireless Personal Digital Assistant as a front-end prototype
1. Visually displayed information presented at any one time by the system should be designed such that the driver is able to assimilate the relevant information with a few glances which are brief enough not to adversely affect driving.

To follow this presentation principle, readable symbols in high-contrast colours and in sufficient size were used to allow an easy recognition of warning messages for construction sites, hazard spots, general information, parking facilities, tram stops and other message types.

2. Internationally and/or nationally agreed standards relating to legibility, audibility, icons, symbols, words, acronyms and/or abbreviations should be used.

All symbols used to support the display of warning messages belong to the group of officially introduced and legally defined traffic signs. Audible warning messages use easy and clear to understand words and have been recorded with high quality for better understanding.

3. Information relevant to the driving task should be accurate and provided in a timely manner.

The comparison of directional heading of the vehicle with stored location of the warning message ensures that only messages in the direction of driving are displayed and announced in a sufficient time ahead of approaching the hazard spot.

4. Information with higher safety relevance should be given higher priority.

Warning messages are classified also by category of safety priority. In the case where more than one message is relevant for one hazard spot, the message with higher priority is announced first.

5. System generated sounds, with sound levels that can not be controlled by the driver, should not mask audible warnings from within the vehicle or the outside.

The system was developed to allow the driver to control the sound level manually before start if driving. In case of coincidentally audible warnings from inside the vehicle, i.e., traffic channel messages announced over the car radio, the latest message from hazard warning can be repeated by simply tapping the screen of the PDA.

7 Outlook

In general it can be assumed that various ways to implement a personalised hazard warning system exist and are feasible by different means. First of all the combination of a traffic safety layer with commercial navigation software is obvious and requires specialised layers for at least the most favoured navigation systems on the market. Each of the adapted safety layers has to be provided over the same broadcast channel. The disadvantage of such diversification is that additional broadcast capacity is necessary for the provision of each thinkable adaptation. A remedy for this downside may be to provide the traffic safety layer over the internet for individual downloads. However the need for additional pre-trip preparations may raise the barrier to use the system at all.

The alternative approach intends to establish a DAB service using the TPEG protocol to transmit voice data and warning messages that can be displayed and announced in a browser based application. The advantage of such a regional broadcasted data service for digital radio is that the software and necessary plug-ins can also be broadcasted and made consequently available for a number of different PDA platforms, whereas the more comprehensive data volume remains platform independent.
8 References


