Vulnerable Road Users thoroughly addressed in accident prevention: 
the WATCH-OVER European project

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Abstract

The European Specific Targeted Project WATCH-OVER is co-funded by the European Commission Information Society and Media within the initiatives of the cooperative systems for traffic safety and efficiency based on communication and sensor technologies. The project, supported by EUCAR, is coordinated by Centro Ricerche Fiat and includes in its consortium vehicle and motorcycle makers, technology, automotive suppliers and research centres for the design, development and testing phase. The core concept of the project, presented in this paper, is to enable the future availability of a modular cooperative system that will bring together sensor and communication technologies permitting to all road users (the vehicles, the motorcycles, the bicycles, the pedestrians) to take an active part in the reduction of the number of accidents that involve vulnerable road users. The paper gives also a highlight of the definition of the relevant cases of use and anticipates the architectural approach.

Keywords

Road safety, vulnerable road users, cooperative systems, communication and sensor technologies.

1 Introduction

Road accidents in the twenty-seven European countries involving vulnerable road users are still an unacceptable number. The WATCH-OVER project is carrying out research and development activities aimed at the design and development of a system for the
prevention of accidents that involve vulnerable road users in urban and extra-urban areas. The WATCH-OVER project started in January 2006. It is a specific targeted project co-funded by the European Commission Information Society Technologies (IST) in the strategic objective "eSafety Co-operative Systems for Road Transport".

The innovative concept is represented by an on board platform and by a vulnerable user module, the system is based on short range communication and vision sensors. WATCH-OVER intends to examine the detection of vulnerable road users in the complexity of traffic scenarios in which pedestrians, cyclists and motorcyclists are walking or moving together with cars and other vehicles.

This paper is presenting the outcomes of the first project activities on the definition of the scenarios and use cases and highlights the most relevant information needed for the development of the WATCH-OVER system.

2 Use cases and relevant scenarios

WATCH-OVER experts considered that a single approach for the definition of the scenarios and use cases would not have been complete as from one side available data on road accidents are not giving a whole picture neither the level of details that are needed to define the relevant scenarios and use cases; from the other side, a systematic approach alone would not have guaranteed that the assumptions made are fully adherent to the real situation. Therefore a multiple approach has been followed: the outcomes from available results of previous projects available results and the survey of accident data have been complemented with the analysis performed in expert brainstorming sessions and benchmarked with a systematic definition of the relevant scenarios, again defined by experts of the WATCH-OVER project.

Additionally the list of relevant scenarios of use has been then submitted to a group of external experts and users (drivers, motorcyclists, cyclists and pedestrians) by means of a questionnaire for an evaluation of the most significant accident configurations. The questionnaires have been structured also to investigate the user needs that should be considered for the WATCH-OVER system, questionnaires are divided into different parts, one gathering the user requirements and inputs for the on-board HMI (Human Machine Interface) and the other part considering the prioritisation of previous scenarios and the possibility to propose new accident situations.

The main outcome of this study has been the selection of eight relevant use cases that are prioritised via their estimated relevance for road safety. These use cases have been parameterised to enable the subsequent definition of system functionality and specifications. The key parameters, identified by experts and evaluated by users by means of an on-line questionnaire, are: type of vehicle and of vulnerable road user, type of road, relative trajectories, vehicle’s and vulnerable users’ speed, time to collision, time of the day, weather. Finally each “use case” has been commented by experts that included a
very preliminary evaluation of their technological feasibility within the WATCH-OVER framework.

The following sketches indicate those scenarios with a high estimated occurrence and a consequent high relevance for road safety as well as those with medium occurrence.

<table>
<thead>
<tr>
<th><strong>DESCRIPTION</strong></th>
<th><strong>SKETCH</strong></th>
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<tbody>
<tr>
<td>Pedestrian (or cyclist) crossing the road from the right to the left.</td>
<td><img src="image1" alt="Sketch" /></td>
</tr>
<tr>
<td>Pedestrian (or cyclist) crossing the road from the right to the left (or from the left to the right) occluded from parked or stopped cars or other obstacles.</td>
<td><img src="image2" alt="Sketch" /></td>
</tr>
<tr>
<td>Vehicle turning left at an intersection, pedestrian crossing the road from the right to the left (or from the left to the right).</td>
<td><img src="image3" alt="Sketch" /></td>
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<tr>
<td>Vehicle turning right at an intersection, pedestrian (or cyclist) crossing the road from the right to the left (or from the left to the right).</td>
<td><img src="image4" alt="Sketch" /></td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>SKETCH</td>
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<td>----------------------------------------------------------------------------</td>
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<tr>
<td>Vehicle on a crossroad, pedal cyclist crossing the road from the right (or from the left).</td>
<td><img src="image" alt="Sketch" /></td>
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<tr>
<td>PTW arrives from left side (or from right side) at intersection, paths perpendicular.</td>
<td><img src="image" alt="Sketch" /></td>
</tr>
<tr>
<td>PTW arrives from left side at intersection, paths perpendicular, occluded from parked car or other obstacles.</td>
<td><img src="image" alt="Sketch" /></td>
</tr>
<tr>
<td>PTW (or pedal cyclist) and vehicle travelling in opposite directions, vehicle turns in front of PTW.</td>
<td><img src="image" alt="Sketch" /></td>
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</table>
3 System reference architecture

The WATCH-OVER system is composed of different components that cooperate at the identification of vulnerable road users that are in a potentially dangerous position in front or nearby a vehicle equipped with the WATCH-OVER system that is driving in the complexity of a urban scenario.

While the vehicle proceeds, a vision sensor (a new generation of high dynamic CMOS cameras) focuses on the frontal part of the car and recognises objects and their motion; a communication module gathers the responding signals in the area covered from the antenna and calculates their relative position; the on-board processing unit collects the different input and output with a certain frequency a data fusion evaluates the risk level of possible colliding trajectories. In case the risk level passes a certain threshold there will be both an alert to the driver and a message sent to the VRU module.

The different actors taking part to the project framework are a car and a vulnerable road user (a pedestrian, a bicycle or a powered two wheelers). The following figure gives an outlook of the scenario’s possible actors.

The vehicle shall be equipped with the vision based sensor, the communication device, eventually a GPS module for absolute localisation and an on-board unit that performs data fusion and evaluates the objects relative positioning. The motorbike (or the moped) shall be installed with a communication system, eventually a GNSS receiver and an on-board unit able to collect and store information on the surrounding traffic flow. The VRU (pedestrian or bicyclist) shall use a wearable communication module for its recognition from the WATCH-OVER vehicles. The following figure depicts the overall system reference architecture.
The WATCH-OVER system functions can be summarised as follows:

On-board platform:
- real-time detection of pedestrians, cyclists, motorcyclists,
- calculation of the relative position of the user vs. vehicles,
- specific warning to the driver in critical situations.

Vulnerable road user module:
- to promptly answer to the vehicle’s stimulus, delivering its identification parameters,
- to send back self-localisation parameters.

From the point of view of the communication technologies, WATCH-OVER requirements for the communication technology are:
- low cost: the cost of the communication device should be acceptable for a wearable device as vehicles, motorcycles, bicycles and pedestrians should be enabled to communicate with each other,
- low complexity of the communication protocol as the communication should only bear the information of “where” and “who/what”,
- low power consumption should be operable with a limited power supply as it has to be integrated into different device typologies,
precise distance measurement as vulnerable user detection should be independent from satellite localisation systems to avoid adding costs and to avoid lack of coverage,

- high reliability of the signal recognition objects should be unambiguously identified.

It is also important to be noted that there is no need for a dedicated frequency band.

WATCH-OVER candidate short range communication technologies are:

(a) IEEE 802.15.4 (Zig-Bee) standard (868/915MHz or 2.4 GHz), data rates up to 250 kb/s:

- low power consumption,
- fast wake-up and association,
- bi-directional communication,
- low cost and complexity.

(b) RFID (Radio Frequency Identification) enables the unambiguous identification of an object by means of an RF wireless system.

(c) IEEE 802.15.3a UWB (Ultra Wide Band Radio) still in its standardization phase. Transmission rates four times higher than WI-FI, halving power consumption:

- low power consumption, low cost,
- precise distance measurement,
- high reliability of signal recognition.

Running activities are now focused on the selection of the most appropriate communication technology to be applied in the WATCH-OVER development.

4 Conclusions

The WATCH-OVER project is working on the design and development of a cooperative system to prevent road accidents that involve vulnerable road users. The project is co-funded by the European Commission, it is supported by EUCAR, is coordinated by Centro Ricerche Fiat and its consortium is composed of the following project partners from six different European countries:

- DaimlerChrysler AG (DE)
- Piaggio & C. S.p.A. (IT)
- Robert Bosch GmbH (DE)
- MIRA Limited (UK)
- Technische Universität Chemnitz (DE)
- Austrian Research Centers GmbH (AT)
- Centre for research and technology hellas (EL)
- Universität Stuttgart (DE)
- Steinbeis Stiftung fuer Wirtschaftsförderung (DE)
• Faber Software S.r.l. (IT)
• LogicaCMG Nederland B.V. (NL)
• Università di Modena e Reggio Emilia (IT)

Project partners are now working on the design of the system architecture, on the development of the new generation of CMOS cameras and on the selection and customisation of the most appropriate communication technologies.

The main challenges that the project is facing are:
• the detection of vulnerable users in the complexity of traffic scenarios in which pedestrians, cyclists and motorcyclists are walking or driving together with cars and trucks,
• the development of a cooperative system for the real time detection and relative localisation of vulnerable users that takes advantage of both short range communication and video technologies,
• the future deployment of a reliable system that is versatile to different vehicles and vulnerable road users.

A first very relevant result is the applicability of the WATCH-OVER system also in the future framework of the cooperative systems for road safety that are under development into the SAFEPOT integrated project, as the two projects had already the possibility to analyse and to design a full complementarity of the different systems under development in light of a future common and unique on board architecture.