LOGGING, ALERT & EMERGENCY SYSTEM FOR ROAD TRANSPORT VEHICLES

An Experimental eCall, Black-box and Driver Alerting System

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Abstract: This paper describes the experimental platform developed at UEM, mounted on a conventional vehicle. It monitors most of the driver's actions on the controls of the vehicle, logs the vehicle speed and position using a GPS, detects and recognizes vertical traffic signs, and records the last seconds of the trip with a panoramic video camera. If an accident occurs, the system calls emergency services (112 in Spain) sending vehicle position information (via SMS) and opening a voice channel.

1 INTRODUCTION

The alert and control system developed in SACAT project (Control and Alert in case of Accident System for road Transport vehicles) is intended to be used in freight and also in human transport by road. It aims to increase security, specially trying to save human lives by decreasing the time until assistance arrives.

EU *White Book* on European Transport Policy for 2010 reveals worrying data. Taking into account all costs, road transport represents approximately 1 *billion* Euros (above 10% EU gross domestic product). Road transport carries 44% of total freight and 79% of total people transportation. Between 1995 and 2003, road freight transport increased 19.4%, while rail freight transport decreased 43.5% in the same period. However, road transport is the most dangerous one, having a terrible cost of human lives, and provoking expensive traffic jams (fig. 1).

EU proposes a two-lined action: agreement in penalties, and the promotion of new technologies in road security. It explicitly establishes that technological evolution will also allow strengthening the usual control and penalty means, using automatic systems and driving-assistance on-board devices. Related to this, EU proposes the use of ***black-boxes*** in vehicles, for registering relevant parameters to analyze the causes of an accident (like in other transportation means).

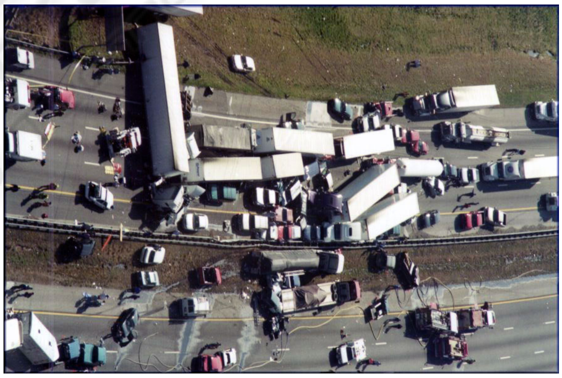

Figure 1: Multiple accident and closed road.

In the same line, EU has adopted a directive, named ***eCall*** (in the E_MERGE program) that will make compulsory the installation of an alerting device in every new vehicle marketed in the EU from 2009 on. This device should automatically alert emergency services in case of accident using mobile phones and GPS (EC,2003).

Another EU measure aimed to improve security in freight vehicles is the obligation of installing ***digital tachometers*** from August 2006 on (in Spain this date has been moved to august 2005 for vehicles above 3,5 tons or 9 passengers).

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The system described in this paper follows all these lines of action in security matters, and puts them together in a single prototype. Furthermore, it adds some functionalities that will surely be included in security directives in the future, such as automatic recognition of traffic signs (Escalera,2003) and real-time alerting to the driver. The whole system tries to lower the risk of accident; and if it finally happens, tries to minimize the time until victims are assisted, and provides critical information for analyzing the reasons.

The developed prototype is composed of two main modules, with the following functionalities:

Black-box. Records the detected signs, vehicle data (speed, position, driver actions) and a panoramic video of the last minutes of the trip.

Alert System. If an accident takes place, the system sends a text message (SMS) to emergency services (112 in Spain). It includes the location of the vehicle (GPS), kind of vehicle and load data (number of passengers, dangerous loads, etc). This is an essential matter, because every minute counts when a person is wounded in a traffic accident. Recent studies established that the probability of an accident victim of surviving is doubled if he/she is assisted in the first 20 minutes after the crash.

Additionally, a bidirectional voice channel is opened in an automatic manner, allowing direct communication between 112 emergency services and the passengers. It can also be manually launched with an emergency button, if a passenger gets ill, or the accident of a nearby vehicle is seem; the vehicle position is also sent to the emergency service, so there is no need to spend precious time trying to tell where the incident is.

In the next sections, the system architecture, the two main modules and the sign recognition subsystem are detailed. Finally, in section 6, the present system performance is described, and the opened lines of work and improvement are discussed.

2 SYSTEM ARCHITECTURE

The system has been implemented on a conventional vehicle Renault Express (figure 2). This model lacks of communication bus, so all the instrumentation and wiring associated to driving devices have been added. The whole system uses the vehicle's 12V battery by means of a 600W dc/ac inverter, sourcing 220 AC volts. This allows using standard equipments.

Figure 2: Test vehicle from SACAT.

The core of the application is formed by a conventional PC and a PDA. The sensorial system includes the following devices:

- *Bluetooth* GPS module
- Mobile phone with *Bluetooth* interface
- Panoramic color CCD camera
- Conventional color CCD camera
- Encoder reading steering wheel movement
- All/nothing sensors for pedals, direction lights, hand brake and contact

The PC hosts the main system interface, feeds the *black-box* (external USB drive), captures panoramic and frontal video, and registers the data from the driver's action sensors. It also processes the frontal camera images for detecting vertical traffic signs.

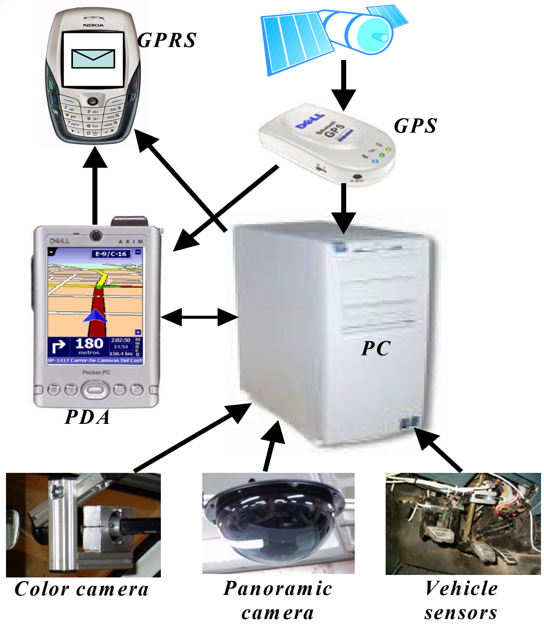

Figure 3: SACAT architecture.

The GPS receiver is used for registering the speed and coordinates of the vehicle; they are stored in the black-box. The mobile phone allows communication (SMS and voice channel) with emergency services when a collision is detected (using the airbag firing sensors) or when the driver uses the emergency button, following *eCall* standards.

The PDA works as a *wireless* interface between the GPS and mobile phone with the PC. It also is used as input device for the system: data about the driver, load, route, etc. is loaded in the central control of the transport firm, and then plugged into the system.

Figure 4: Interface devices in SACAT.

3 LOGGING SUBSYSTEM

This subsystem is responsible of saving relevant information from the system such as video, sensor and GPS data, etc. This module is called "Black-box" because of their similarity to the ones in airplanes.

Panoramic video (fig. 5) is recorded by saving periods of time in several consecutive files; the oldest one is deleted each time a new file is saved, to avoid running out of storage space in a long trip. This way, the last images of the environment around the vehicle before an accident are left available for posterior analysis. This information facilitates finding the causes of the accident (to avoid them in the future), and clarifying responsibilities for it. The video recording is done as a background process and doesn't interfere with the other processes of the system.

Figure 5: Panoramic video.

Images are obtained using a 3D Sony CCD camera mounted on the roof of the vehicle. When the vehicle is stopped for a significant time during a trip (to rest or have a break, for example), a separate group of video files are saved, acting as a surveillance device.

The sensor information is obtained from several driving devices, such as pedals (clutch, brake, and accelerator), steering wheel, indicators, hand brake, and contact. The sensors are read using a data acquisition card in the PC. The information gathered is saved in the black-box's database each time it changes. A timestamp is added for each entry.

Position and Speed of the vehicle are obtained from a *bluetooth* GPS device in the PDA (where a navigation application can be run), and sent to the PC via *wireless*. This information is also saved in the black-box database.

When an accident occurs, the last GPS position (and other relevant information, see next section) is sent to the mobile phone, and then to emergency services.

The aim of this black-box is to store a log of the trip, and specially a log of the environment and the last actions of the driver just before an accident.

4 ECALL SUBSYSTEM

In this section, the alerting module of the system is described. It is designed to be adapted to the rules established by the European Commission (EC), the

European Association of Vehicle Manufacturers (ACEA) and the multi-sector public/private-partnership for the implementation of Intelligent Transport Systems and Services (ERTICO). These entities work for the introduction of an emergency call system that will be automatically launched in case of accident, named ***eCall***. This system will automatically alert emergency systems and provide them with critical information about the accident.

eCall has therefore the potential to greatly reduce the number of fatalities, the severity of injuries and the stress in post-crash situations, by speeding up the response of the emergency services and allowing to choose the adequate material and human resources needed for each accident.

This emergency call module incorporates this functionality, and some others, according to the configuration shown in figure 6.

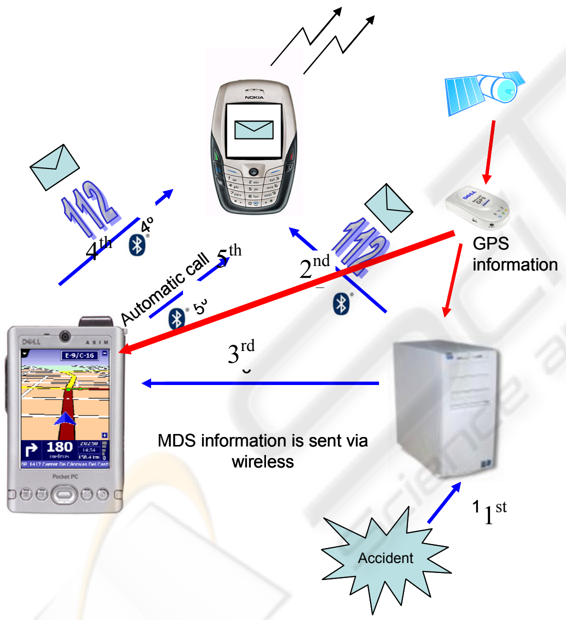

Figure 6: Emergency call module.

Figure 6 shows the hardware elements involved in the emergency module, and the steps given after an accident occurs. Hardware architecture is composed of a GPS receiver, the main PC, a PDA and a mobile phone with *Bluetooth* connectivity.

If an accident occurs, the PC receives the airbag signal, and then activates the emergency module. This module sends an SMS via the mobile phone to the corresponding PSAP (*Public Safety Answering Point*), 112 in Spain. The message sent to the PSAP should contain the so-called *MDS* (Minimum DataSet). This minimum set of data consists of the following information: *"When", "Where" and "Who"* (E-merge,2004).

This information is considered the minimum needed for speeding up emergency services' response with the adequate resources. The message sent contains the instant of the transmission 'hh:mm:ss' ("When"), the latitude, longitude and movement direction of the accident ("Where"), and information about the driver and the load of the vehicle ("Who"). With the standardization of the e-Call information, messages will be adapted to the same model for all countries. The system implemented in this project could be easily adapted to send the so-called *FDS* (Full DataSet) that would contain additional data (enterprise information, insurance data, etc.). The idea promoted in the European program is to send a MDS to the PSAP and more detailed information to a private service provider (PSP).

Considering the importance of the emergency message, after sending it for the first time, the PC sends a signal and the information to the PDA, that will be in charge of two different tasks: sending again the message via mobile phone, and establishing a voice call to make possible to the emergency services to talk with the vehicle occupants if conscious. This call can also be manually established.

5 SIGNAL RECOGNITION SUBSYSTEM

Detection of vertical traffic signs is a classic application for computer vision researchers, that still remains unsolved (except in particular and controlled situations). In the last decades, promising results have been obtained thanks to new computational techniques ((Bahlmann,2005), (Escalera,2001), among others) but surprisingly very few systems has been integrated in a real vehicle with some success, as for example (Priese,1994) in their vehicle VITA II. The system developed in our project SACAT, although far from being commercial, opens real and promising experimentation and improvement ways.

The traffic signs recognition module integrated in the system tries to detect and then read the vertical signs present along the road. This is done aiming at:

- Logging the signs in the Black-box's database.
- Alerting the driver in dangerous situations, such as:
  - Over speeding
  - Overtaking prohibitions
  - Crossroads, Stops, Give way signs
  - Curves, slopes, road works

This module uses a color CCD camera with adjustable zoom, mounted inside the vehicle and aiming at the movement direction. Each image is processed following the these steps:

Step 1: Sign detection.

First, objects candidate to be signs are detected and isolated. A color segmentation, followed by a shape analysis, are used for this purpose.

Color segmentation is done in HLS space, using a parametrization learned off-line with a genetic algorithm. It results in a series of objects that are subjected to a shape analysis (figure 7).

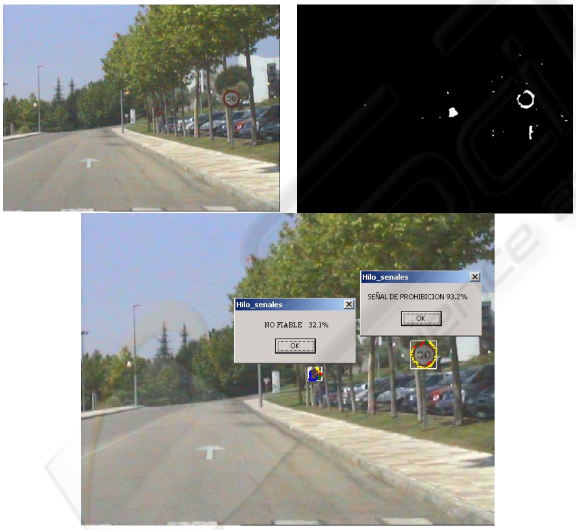

Figure 7: Color segmentation and shape analysis.

The shape analysis is done by first filtering by geometric restrictions, followed by a probabilistic adjustment of straight and curve lines to the shapes (Blake,2005), (Gonzalez,2002). Objects surviving both processes have a high probability of being traffic signs, because at least they have the right colors and shapes.

Step 2: Sign reading and interpretation.

Objects surviving first step filtering are passed to the reading phase. The content of the objects is matched with a data base with the legal traffic signs. This is based on correlation matching techniques with dynamic deformation.

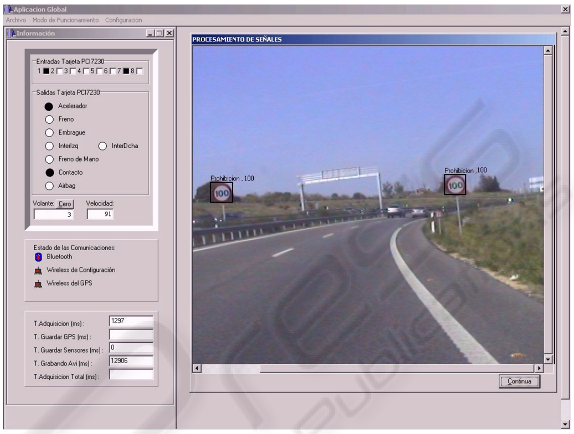

Figure 8: Reading and interpretation.

The final result is an interpreted sign (figure 8), that is logged into the black-box's database, and can be used for driver alerting policies. If the interior of the object is not recognized, it is discarded.

6 CONCLUSSIONS AND FUTURE WORK

The prototype described in this article, developed within the SACAT project, has been driven in tests for more than 5000 km. Its current state and performance is as follows.

The Black-box module is fully operative, logging data of the vehicle and trip every second. The output of this module can be adapted to any of the upcoming UE standards for this kind of systems.

Within this module operates the signal recognition subsystem, that currently works with vertical danger and prohibition signs. This subsystem is currently in a full experimentation and improvement phase, having promising results:

- Right recognition in 83% of danger and prohibition signs
- 5% confusion between similar signs at long distances (2% short distances)
- Detection distance between 10 and 50 m

- One image per second processing

Alert module is also fully operative. Results highlights in crash simulations (alert messages were sent to a private mobile phone) are:

- SMS with the *MSD* successfully received in destiny: 98%. A few SMS were lost or not sent in absence of coverage.
- Voice channel successfully established when coverage available (95%).

Future improvements we are currently working in are:

- Enhancing traffic sign recognition subsystem by:
  - Improving system robustness.
  - Including informative panels to the set of signals handled.
- Detecting road lines and lane markings for preventing involuntary lane changes
- Using *optical flow* techniques to estimate distances to other vehicles and to the road limits (active radar). This helps the driver to keep secure distances.
- Improving communication with emergency services using UMTS (3G) technology. This allows to establish a video call as well as a voice call, allowing to evaluate the state of the vehicle and its occupants.

REFERENCES

European Comission (DG Enterprise and DG Information Society), *eSafety forum: Summary report 2003*, March 2003.

A. de la Escalera; J. Mª Armingol; M. Mata. *"Traffic Sign Recognition and Analysis for Intelligent Vehicles"*. Image and Vision Computing 21, pp 247-258, 2003 .

E-merge final report June 2004 IST-2001-34061. http://www.gstforum.org/en/subprojects/rescue/about_gst_rescue/introduction/e-merge.htm

Claus Bahlmann, Ying Zhu, Visvanathan Armes, Martin Pellkofer, Thorsten Koehler: *"A System for Traffic Sign Detection, Tracking, and Recognition Using Color, Shape, and Motion Information"*. IEEE Intelligent Vehicles Symposium (IV 2005). 2005.

A. de la Escalera, J. M. Armingol,, M.A. Salichs. "Traffic Sign Detection for Driver Support Systems". 3rd International Conference on Field and Service Robotics, pp 141-146.Espoo, Finlandia. June 11-13, 2001

Priese, Lutz and Klieber, Jens and Lakmann, Raimund and Rehrmann, Volker and Schian, Rainer. "New Results on Traffic Sign Recognition". Proceedings "Intelligent Vehicles Symposium '94".pp. 249-254. 1994.

Andrew Blake and Michale Isard. "Active Contours. The Application of Techniques from Graphics, Vision, Control Theory and Statistics to Visual Tracking of Sahpes in Motion". Springer-Verlag Berlin Heidelberg. New York. ISBN 3-540-76217-5

E. González, V. Feliú, A. Adán, L. Sánchez. "Descriptores de Fourier para identificación de objetos en entornos 3D". http://www.isa-cr.uclm.es/xxvjornadas/ConfMan_1.7/SUBMISSIONS/140-liezgarthg.pdf