System for effective Assessment of driver vigilance and Warning According to traffic risK Estimation

IST-2000-28062

PROJECT PRESENTATION

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Project Logo*:

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List of participants

Contractors	Country	Role
Centre for Research and Technology Hellas / Hellenic Institute of Transport	Greece	CO
C.R.F. Societa Consortile per Azioni	Italy	CR
Siemens Automotive	France	CR
Centre national de la Recherche Scientifique – Delegation Midi-Pyrenees	France	AC
Institute of Communication and Computer Systems	Greece	CR
Belgisch Instituut voor de Verkeersveiligheid vzw	Belgium	AC
DaimlerChrysler AG	Germany	CR
University of Stuttgart, Institut fuer Arbeitswissenschaft und Technologie-management	Germany	CR

* Provisional, may change later according to new designs.

Navigation Technologies b.v.	Netherlands	CR
Swedish National Road and Transport Research Institute	Sweden	CR
Autoliv AB	Sweden	AC
University of Basel, Psychiatrische Universitaetsklinik Basel	Switzerland	CR
ACTIA S.A.	France	CR
Centre national de la Recherche Scientifique – Delegation Alsace	France	CR
Nedelrandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek TNO	Netherlands	AC
Technische Universiteit Delft	Netherlands	AC

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1. Project Main goals

The objective of AWAKE is to increase traffic safety by reducing the number and the consequences of traffic accidents caused by driver hypovigilance. In order to achieve this objective, AWAKE intends to develop an unobtrusive, reliable system, which will monitor the driver and the environment and will detect hypovigilance on line, based on multiple parameters. The system will achieve enhanced reliability and minimised false alarm rate, by supporting continuous, instead of discrete, event-related driver monitoring, strong system personalisation to driver characteristics and traffic situation awareness. In case of hypovigilance, the system will provide an adequate warning to the driver, with various levels of warnings, according to the estimated driver's hypovigilance state and also to the estimated level of traffic risk. This system will operate reliably and effectively in all highway scenarios.

More specifically, the objectives of AWAKE are:

- ➔ To enhance traffic safety by reducing the number of drowsiness-related accidents.
- ➔ To enhance the quality of life and safety of European citizens through support during long-term and/or adverse conditions driving.
- ➔ To enhance public awareness of the drivers' drowsiness problem and promote AWAKE concept through innovative dissemination strategies.
- ➔ To develop a **Hypovigilance Diagnosis Module (HDM),** that will detect and diagnose driver hypovigilance on line. This system will fuse, via an artificial intelligence algorithm, data from on-board driver monitoring sensors (such as an eyelid and a steering grip sensor) as well as driver's behavioural data (i.e. from lane tracking sensor, gas/brake and steering position sensors). HDM will then be strongly personalised to the driving characteristics of each driver (exerting continuous driver monitoring and expert-based adaptation) with the aim to achieve a diagnosis level over 90% and false alarm rate below 1% in all highway scenarios.
- ➔ To develop a **Traffic Risk Estimation (TRE) module**, to assess the risk of the traffic situation. This system will match data from an enhanced navigation map, anticollision radar, speedometer and driver's gaze direction sensor, following a deterministic approach. It is not meant as a new system to estimate traffic risk, but rather an expert combination of the output of existing systems in order to rationalise HDM output and DWS warning strategies. The results of this system will be taken into consideration by the HDM for re-assessing the driver's state as well as by the DWS, to decide on the level of warning to provide to the driver.
- ➔ To develop an optimum, modular, on-time **Driver Warning System (DWS),** using acoustic, visual and haptic means. Various levels of warnings will be considered, according to the risk level estimation and driver's estimated vigilance status.
- ➔ To develop a **Hierarchical Manager**, to co-ordinate all the above subsystems.
- ➔ To integrate all the above subsystems and sensors in a single unit (AWAKE unit), appropriate for real-life automotive applications (in terms of cost, dimensions, weight, reliability, robustness, etc.).
- ➔ To diversify and adapt the sensors and subsystems to support: a middle and an upper class passenger car and a heavy vehicle demonstrator, in order to cover all relevant application fields.

2. Technical approach

Project work commences with user needs analysis from the point of view of systems developers, service providers, society, but mainly the drivers, regarding driver hypovigilance monitoring and warning. Through a drivers-oriented PC-based tool, expert interview forms, the relevant general drivers needs are being defined. Particular emphasis is given to specify the needs of priority drivers cohorts for hypovigilance support (such as young drivers, shift workers, professional drivers, people suffering from sleep diseases). In parallel, the relevant legal and insurance policies aspects are surveyed, in order to result in barrier-free implementation scenarios for such systems.

Based on the above, the AWAKE System Architecture and functional specifications are drafted and constantly revised throughout the project, including a detailed list of on-board requirements in terms of sensors and subsystems, project application scenarios of use and a Failure Modes and Effects Analysis of all key system elements.

AWAKE system consists of several subsystems, components and sensors. For the System Architecture design they are distinguished in five functionally different, inter-related subsystems/systems that make up the integrated AWAKE system/unit. These five subsystems are the Hypovigilance Diagnosis Module (HDM), the Traffic Risk Estimation (TRE) module, the Driver Warning System (DWS), the Driver Identification Module and the Hierarchical Manager (HM). All the subsystems consist of several sensors/subsystems necessary for a reliable characterisation of the risk level respectively. The preliminary system architecture is presented below.

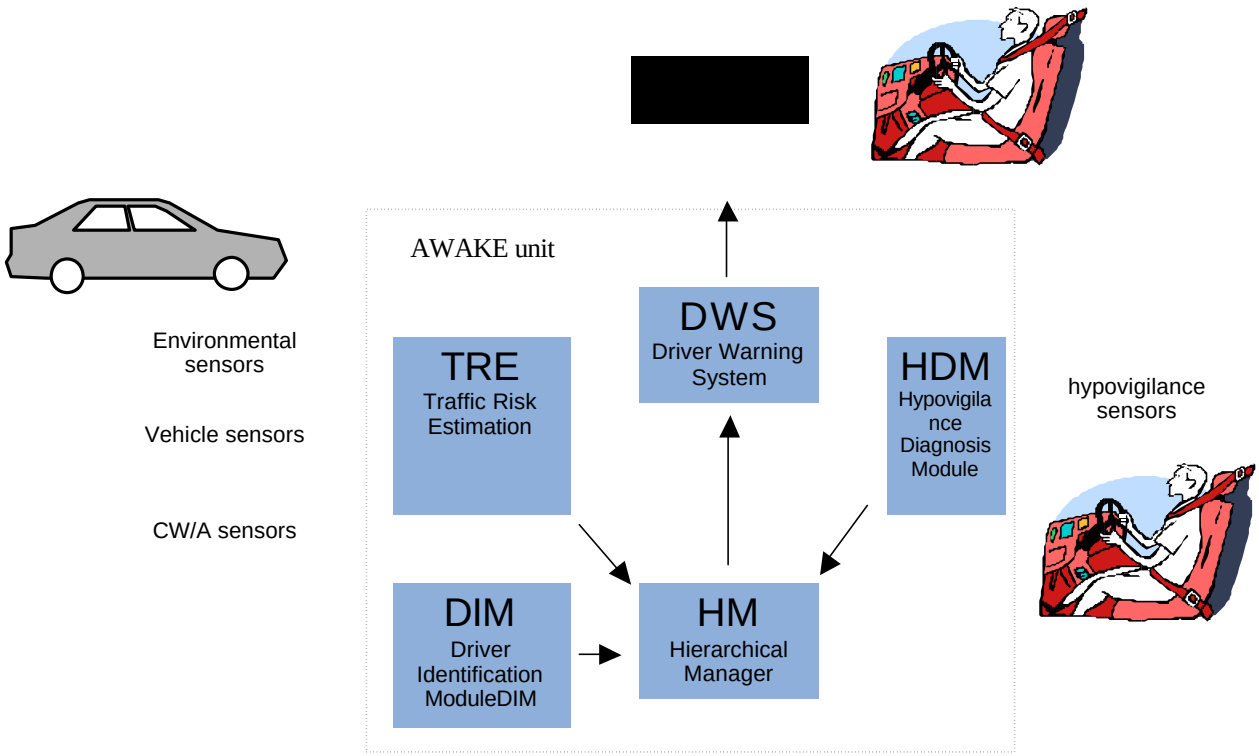

Figure 1: Preliminary System Architecture of AWAKE

Within the above framework, the work to be done starts with the correlation of various physiological and behavioural driver parameters to his/her hypovigilance state and the further improvement of existing sensors for driver hypovigilance diagnosis (such as eye-lid movement, steering grip and lane tracker sensors). The Hypovigilance Diagnosis Module (HDM) for highway scenarios is being developed by data fusion of the most relevant recordings of the previous sensors. Data fusion is primarily stochastic-based, but in parallel a deterministic HDM version is being realised, to act as data filter to the probabilistic one and also to constitute its fall-back position. Finally, HDM is adapted also for heavy vehicle applications.

The Traffic Risk Estimation (TRE) module is also being developed, by correlating vehicle sensor data on imminent risk (such as radar-based obstacles and other cars), with a map database of critical landmarks (i.e. sharp curves, highway entrance/exits, curves after long straight sectors of road), and driver risk awareness through a driver gaze detection sensor. This module does not fuse relevant data but only correlate them through knowledge-based deterministic rules in order to re-evaluate the actual traffic risk and adapt to it the relevant driver warning strategy, thus enhancing overall system reliability, reducing false-alarms and promoting driver acceptance.

Driver warning is based upon a modular approach, defining different warning strategies and elements, depending upon the level of measured drivers hypovigilance, the estimated traffic risk, driver's particular type and application type (i.e. city-cars, luxury cars, heavy vehicle application). The use of innovative kinaesthetic elements (i.e. sound emulated rumble strips) is being researched and a smart-card based driver

identification module is being built for automatic DWS personalisation and further HDM training with the particular driver's behaviour.

The different modules (HDM, TRE and DWS), controlled by a state-event-manager, the Hierarchical Manager (HM),which, together with the vehicle sensors, are integrated in a modular system, that is installed in three demonstrators: a city car, a luxury car and a heavy vehicle. Moreover, thanks to the DIM, driver's personalized data are introduced to the HM through a smart card increasing the "expertness" of the overall system.

Consequently, AWAKE System Architecture is a key issue in order to be able to integrate such a diversity of sensors and systems from different suppliers into a common platform that is robust, stable and yet easily adaptable and expandable.

18 Verification Pilots will take place, by using dynamic car and heavy vehicle driving simulators, research vehicles and the three above defined project demonstrators. They include a thorough technical verification of project subsystems and sensors, acting as a project milestone which determinates the continuation of the project. Pilot objectives fluctuate from single parameter, sensor and/or subsystem verification to usability, acceptance and/or reliability assessment of AWAKE modules and integrated system.

An effective dissemination (with project logo, poster and pamphlet in 8 languages, publications, WWW site, Workshop, video) and exploitation scheme (distinguishing 9 products and their preliminary marketing plans) follows, in order to diffuse and exploit project results.

Project accumulated experience and findings will be transformed into design guidelines for the relevant industry and policy recommendations to authorities.

3. Expected achievements

A modular system (AWAKE), that can be installed in city and luxury passenger cars and heavy vehicles, to:

- predict driver's hypovigilance in all highway scenarios with recognition rate over 90% and false alarm rates below 1%;
- successfully and safely warn the driver about his/her hypovigilance state;
- contribute to the reduction of accidents caused by driver's drowsiness.

4. Expected impacts

Traffic crashes constitute one of the largest public health problems in industrialised countries. In the USA almost half of the deaths of 19-years-olds are caused by traffic crashes, and the total number of pre-retirement years of life cost because of traffic

crashes is approximately equal to deaths caused by the combined effects of the two leading diseases, cancer and heart diseases.

Over 30% of accidents may have as primary or secondary cause the driver impairment, due to a variety of reasons. Also almost 30% of accidents could be avoided by means of reducing the driver related reaction time by just 0.5 sec (through warning by AWAKE system).

The above reasoning allows to believe that a successful application of the AWAKE concept will have important impact on road safety, namely it may seriously reduce accident rate. Still, this is far from certain. Although no model exists which can predict the actual safety effect of a new intervention, the results of previous interventions suggest some fairly stable patterns. Thus, better brakes and handling, poor-weather vision and drowsiness detection are expected to lead to faster driving, faster cornering, faster speeds under low visibility, and longer-duration driving.

Hence, only after the behavioural effects of AWAKE system have been studied (in its pilots) the actual impact to traffic safety will be estimated. If we do not consider possible negative effects (i.e. from over-reliance to the system), hoping to avert them by proper system implementation, we may result in erroneous assumptions.

On the other hand, the introduction of other ADAS into traffic (such as obstacle avoidance, vision enhancement, route guidance and lane keeping) may well induce subjective fatigue and stress or boredom to the drivers, leading to even more monotonous driving conditions. Thus, the need for driver monitoring and drowsiness detection systems will be further enlarged.

The total cost of crashes in EU is 50 billions Euros. Worldwide, more than half a million people are killed each year in traffic crashes. Approximately one person in 200 in the world's population dies from injuries received in traffic crashes while about 15 million people per year are injured in traffic crashes worldwide. This means that the average citizen of the world has about one in seven chance of being injured in a traffic crash sometime during ones life. Furthermore, it has been estimated that the average vehicle has about a 20% probability of being involved in some type of crash per year.

More specifically, sleep-related accidents in the USA are annually associated with more than 23,000 fatalities, more than 2 million injuries and cost over 56 billion Euros.

In economic terms this means that:

- Around 70 billion Euro are spent each year on medical treatment of injured people in accidents and thousands man-years of work are lost. These numbers are bigger than the Gross Product of several EU countries!
- Social funds of magnitude also of billions Euro are devoted yearly to medical services and rehabilitation for people, becoming temporarily or permanently disabled due to accidents.

A large proportion of all the costs are paid directly, or reimbursed, by insurance companies, which therefore have a very significant interest in traffic safety enhancement.

The benefit to the economy throughout Europe is therefore obvious, even if AWAKE manages finally to prevent only a limited number of incidents, as, for example, a mere 5% reduction to road casualties means about 2,500 less deaths and 75,000 less injuries per year, which sums up to around 500 MEuro gain annually for the European economy. Also since accidents due to loss of vigilance tend to be more severe than the average, that figure may be even an underestimation of the actual economic gain.

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Annex 1: Indicattive pictures of subsystems

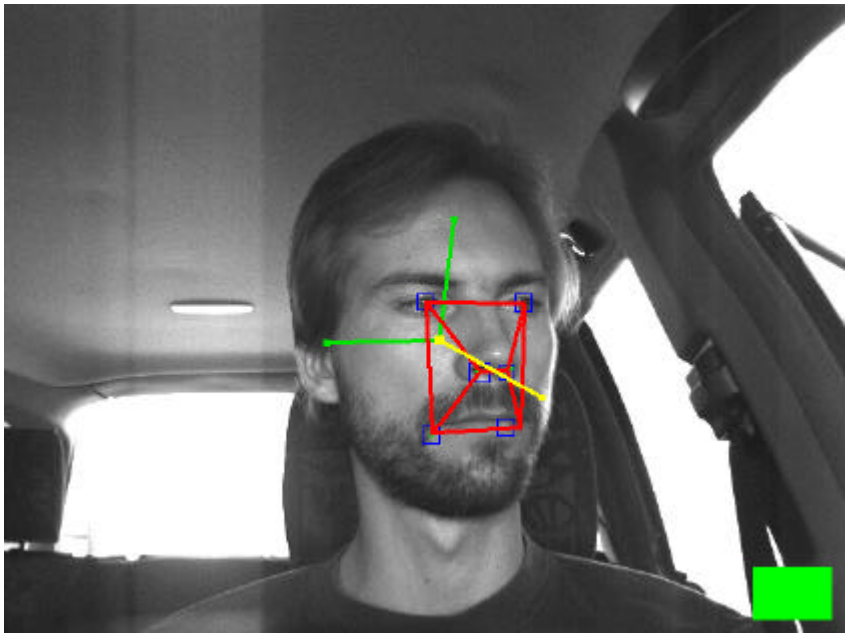

Figure 2: Functionality of eye gaze sensor

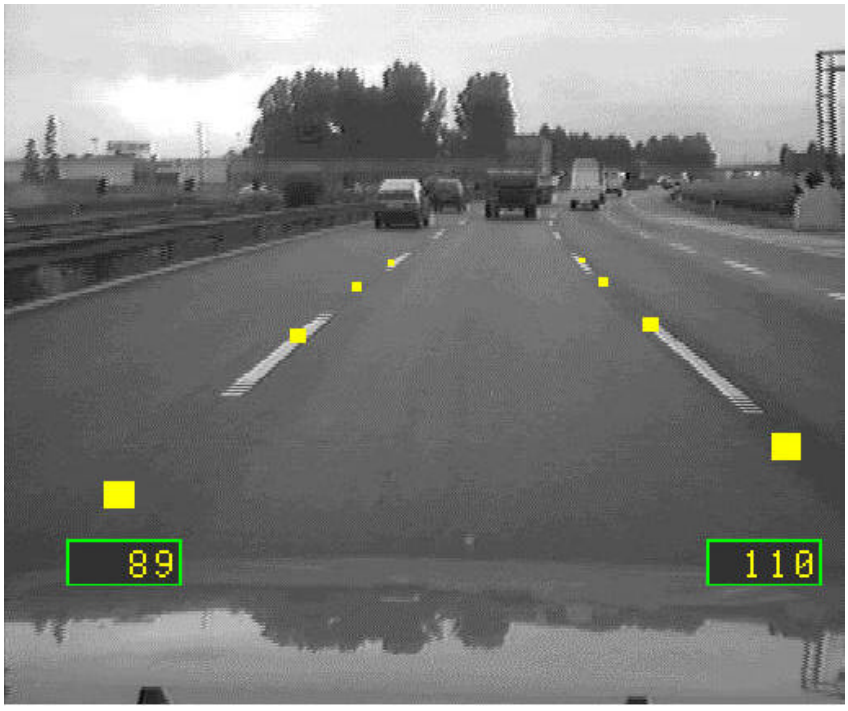

Figure 3: Lane recognition subsystem

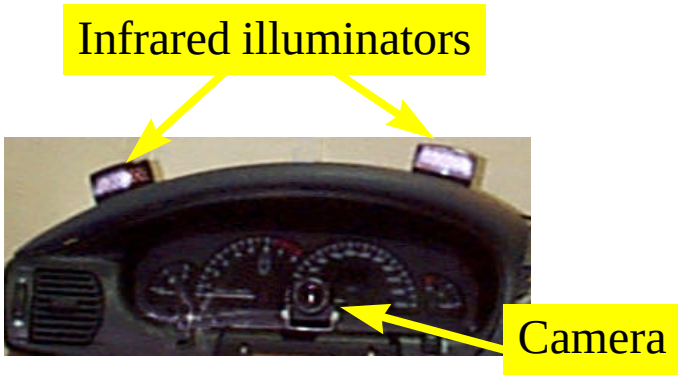

Figure 4: The eyelid sensor

Figure 5: The localisation subsystem