Approach used to merge the different driver monitoring diagnostics in the AutoConduct project

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BOOK OF ABSTRACTS

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ABSTRACT

Driving automation, either level 3 (including unplanned manual control recovery) or level 4 (fully automated driving on specific road sections), introduces new safety and acceptance issues. In order to improve road safety by integrating advanced safety technologies, we must ensure that this new technology takes into account the needs and expectations of the drivers, on the one hand, and the predicable changes in user behaviour, on the other hand. A Human Factors working group, bringing together the main French actors of driving automation, has been set up within the NFI plan (investment plan for the future) “autonomous driving” to prioritize these issues (www.economie.gouv.fr/files/files/PDF/nouvelle-france-industrielle-sept2014.pdf).

Project presentation

AutoConduct aims to design a new Human-Machine Interaction (HMI) based on needs analyses and adapted to the driver’s condition in response to the priorities identified by this working group. For this purpose, the current project offers advanced monitoring of the driver by combining different diagnoses (physical state defined by the posture, internal states defined by emotions and cognitive load, and perceptive state defined by visual strategies) to adapt the management of interactions between the driver and the vehicle automation in real time. The originality of this project is

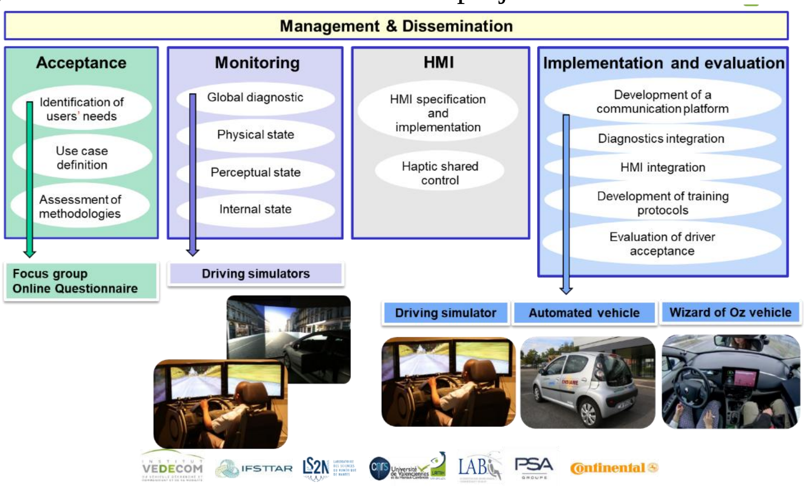
- To adopt a user-centric approach based on the needs of human factors and ergonomics;
- Consider acceptance (a priori and after experience with the system) at the early, design stages of automated vehicle, which, until now, were developed primarily based on technological criterion;
- To treat the driver’s state through objective measures of indicators on three

dimensions: physical, perceptual, and internal (attentional and emotional);

- To develop a progressively shared vehicle control (i.e. cooperation) based on a physiologically valid sensorimotor control model.

The project has been divided into several phases (Figure 1). The first one consisted in a study on acceptance to gain knowledge about the potential needs of the users in realistic cases of autonomous driving and recovery from surveys and interviews. The aim was also to specify possible HMC (Human Machine Cooperation) scenarios used in the subsequent stages of the project The second phase consisted in the design of different technological blocks to monitor the state of the driver characterized by physical, perceptual and internal dimensions. For that, studies have been designed to get new knowledge on the measurements characterizing the driver states and to develop tools and methods to obtain indicators on these states in real time on the three physical, perceptive and internal dimensions. The third phase ‘HMI - Interaction Management’ aims at designing a progressive shared control system between human and vehicle and an acceptable HMC manager adapted to the driver state. The work of the two previous phases has been integrated on a single simulator in order to provide a diagnostic of the driver states in realistic use cases. Finally, a phase of ‘Implementation and evaluation’ will then be able to evaluate the integration of these developments done in the partner vehicles.

Figure 1. Organisation of the AUTOCONDUCT project

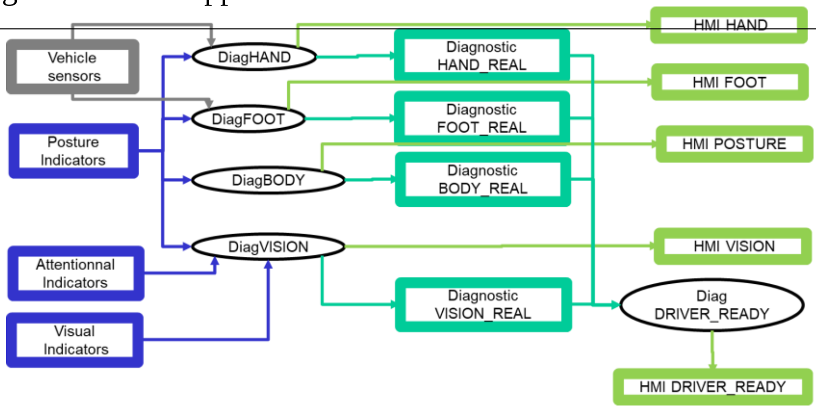


The advanced driver monitoring system and the interface developed by the project has been integrated in two instrumented vehicles. A Wizard of Oz instrumented vehicle (i.e. the active controls are managed by a professional driver hidden from the driver’s view) integrates driver monitoring to test robustness of diagnostics on public roads. A second instrumented vehicle integrate the active controls of the speed and direction of the vehicle, to test the acceptance and robustness of HMI in a controlled environment (i.e. test track).

The diagnostic fusion approach

The monitoring of driver’s state is based on 3 different types of indicators (Figure 2). The posture module gives some information on the position of the body, the legs and the hands. The visual strategy module gives some information on the position of eyes and on the dynamic visual behaviour. The attentional diagnostic gives information on the driver’s attentional level. In addition, some information is given by the vehicle module in terms of driver’s actions like pedal and steering wheel movements.

Figure 2. Diagnostic fusion approach



The fusion of these indicators is done in two steps. The first one makes the fusion of several indicators to provide diagnostics: posture and vehicle information to improve the BODY, HAND and FOOT diagnostics, posture, visual and attentional indicators to improve VISION diagnostic. The second step will use these diagnostics to create the final one: DRIVER_READY. The fusion process creates two type of diagnostics. The real diagnostics provide ternary values (Ok, NoOk and undefined) and the HMI diagnostics provides binary value (Ok, NoOk) needed to manage the Human Machine Interaction. The fusion process is done with rules, which define for every combination of input diagnostic values the output diagnostic value. For example, the table 1 define the rules used to create Driver_Ready diagnostic from Posture, Hand, Foot and Vision real diagnostics.

Table 1. Rules used to create Driver_Ready diagnostic

DRIVER_READY	**POSTURE**	**HAND**	**FOOT**	**VISION**
NoOK	NoOK	All	All	All
NoOK	OK	NoOK	All	All
NoOK	OK	OK	NoOK	
NoOK	OK	OK	OK	NoOK
OK	OK	OK	OK	OK
ok	OK	OK	OK	Undefined
NoOK	OK	OK	Undefined	NoOK
OK	OK	OK	Undefined	OK
OK	OK	OK	Undefined	Undefined

From a useful point of view, this type of table facilitates exchanges between researchers from different disciplines. Indeed, each line describes a well-defined and concrete situation. From an implementation point of view, this approach makes it possible to define which diagnoses are used in priority. It allows an exhaustive coverage of all the possibilities of combining diagnoses.

In conclusion, this project has shown that it is possible to merge diagnostics of very different natures with an exhaustive coverage of the possibilities and to discuss the merging rules with a multidisciplinary team thanks to an exchange format understandable by ergonomists as well as engineers.

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